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Agricultural Research and Development in the Southwest Sudan

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PART I: THE ZANDE SCHEME

The devising of an agricultural research policy for the development of the southern Sudan and Equatoria Province in particular is but a small fraction of the world problem of the so-called underdeveloped territories. (With official endorsement from UNO, the term 'backward' has been dropped in favour of the term 'underdeveloped'. 'Backward' involves subjective judgement, 'underdeveloped' is simply an objective statement and carries no stigma.) Since 1945 much thought and consideration has been devoted to this major agricultural problem, especially on the part of powers responsible for territories overseas. In fact one of the most significant trends of post-1945 policy has been the increasing realization by leading nations of their joint responsibility for the betterment of the underdeveloped territories. This concern on the part of governments and authorities touches agricultural research policy at all points. Land is the greatest of all natural resources and its right use for food production and other agricultural products must always remain the first objective of agricultural research policy.

THE PROBLEM OF THE SOUTH

There are few less developed areas in Central Africa than the southern Sudan and in the case of the Zande district of Equatoria, there must be included the additional factors of geographical and economic isolation. The southwest of the Sudan, here considered in some detail, comprises the broad-leafed woodland and forest region with a rainfall of 40 to 60 in. and was described by Andrews (1952). No fertilizers are available for the impoverished soils, there is little animal husbandry and hence no supply of farmyard manure. There are difficulties of marketing and little incentive for the production of crop surpluses. Last but not least is the human factor. The indigenous population is robbed of vigour of mind and body by chronic infections, which in the Azande‡ particularly reduce initiative and drive. In spite of much trial and effort this region, both from the agricultural and economic standpoint, remains today one of the most intractable of the tropics.

The Yambio Experimental Station of the Research Division of the Ministry of Agriculture, which in due course should develop into the

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* Formerly Senior Chemist
† Formerly Senior Agronomist
‡ Zande, pl. Azande.
The Azande are a large tribe of mixed Sudanic and Bantu origin occupying the Zande District (Zandeland) of southwest Equatoria. The district has a population of about 168,000 and many more Azande are to be found in the neighbouring districts of the Belgian Congo and French Equatorial Africa. They have always been agriculturalists and not pastoralists.

Southern Provinces Research Station, is located in the heart of this region. The existence of better soils and climatic conditions, together with the choice of Zandeland as the locus for the inception of Tothill's scheme of social emergence, influenced the decision to establish the research station at Yambio, which was founded in 1947.

The development of the three southern provinces of the Sudan, viz. the Upper Nile, Bahr el Ghazal and Equatoria, has of necessity been slower than that of the six northern provinces. There are several reasons for this. When the Sudan was taken over in 1898 by the Condominium Administration the southern area was the most primitive and inaccessible part of the country. Secondly, it was logical to develop the main cash crop—cotton—on which the economy of the country depends, in the favourable conditions of the Gezira in the Blue Nile Province and other northern areas such as the Gash and Tokar deltas. These, with the production of American Upland cotton in the Nuba Mountains, form the economic backbone of the Sudan. Thirdly, the economic depression of 1929–32 and the outbreak of the 1939–45 war were other significant factors precluding earlier development in the south.

Nevertheless, there is evidence of the concern and foresight of the Government in the formulation of schemes for research and development in the south. As long ago as 1940 Tothill (1948a), then Director of Agriculture, raised the question of sugar growing along the line of the Nile silts as a possible development scheme for Equatoria. In the same way, the ' Zande Scheme ', as it is now known, came into existence later on, being sponsored by the same authority. Whatever measure of success these and other development schemes may ultimately achieve it must always remain to the lasting credit of the Administration of that time that it responded before the full impact of the effects of post-1945 conditions and thinking were felt in the world outside. In particular the Zande Scheme, which has aroused so much interest and discussion in scientific and administrative circles, must always remain a testimony to the foresight and enlightenment of the Sudan Government whatever the destiny of the scheme may be.

ECOLOGICAL SURVEY OF EQUATORIA

The decision to undertake an ecological survey of the southern Sudan in 1935 was further evidence of the determination of Government to implement its development. It was realized from the outset that the area must remain self-supporting, with its export products confined to high value commodities which might justify the cost of long distance transport.

Accordingly, J. G. Myers was appointed in 1937 to undertake this ecological survey of the south, in conjunction with a reconnaissance soil survey by H. Greene and O. W. Snow. The survey covered the provinces of Bahr el Ghazal and Equatoria and formed the basis for a programme of systematic plant introductions and field trials. Myers also stressed the importance of extending the survey so as to include investigation of the peasant diet before changes were introduced. Some important conclusions were summarized in his map of southwest Equatoria, which defined the districts considered to be suitable for the growing of coffee and cotton. He worked out a useful classification of this region into so-called ' green ',

' blue ' and ' red ' belts, mapped on the basis of soils and vegetation. In short, MYERS's (1937–42) survey can be regarded as the forerunner of the Zande Scheme and laid the foundations for its implementation. His tragic death in a road accident in 1942 cut short this great work, which unhappily has never been published. Truly the south owes its debt of gratitude to this shrewd and gifted investigator.

For this survey Myers used the Kagulu Station, situated near Yei, as his headquarters. This former forestry station of the Belgian Congo has been used by the Sudan administration mainly for agricultural and forestry research. Kagulu, the oldest agricultural station in the south, has areas of different timber trees, *Citrus*, plantation crops and subsistence crops under investigation. Under the direction of H. Ferguson, Kagulu has played no small part in the essential work of new introductions and field crop trials. Later the station developed into a Government Training Centre for Sudanese agricultural staff and was the forerunner of the Agricultural Training School established in 1947 at Yambio.

GENERAL AGRICULTURAL POLICY

Before considering the first major scheme for research and development in the south it may be useful to examine the general agricultural policy of the Sudan. Tothill stated broadly that the ' social emergence ' of rural communities is the basis and touchstone of all agricultural policy and that it is now possible to contemplate the process of emergence at a quickened pace. Although the term ' social emergence ' has never been strictly defined, it is taken to include progress and stability, and generally to have to do with the betterment of Man's estate. TOTHILL (1948b) described the aim of this policy as ' the emergence of happy and prosperous rural communities rapidly becoming fully literate, financially able and mentally wishing to participate in the advance of civilization and taking an ever-increasing interest in the management of their own affairs '. At the same time he emphasized that social emergence is only possible if ' based solidly upon the productions of the soil '.

At the time the Condominium Powers assumed the burden of government they found a country literally torn by fire and sword, by disease and slavery. The first task was the obvious one of the restoration of law and order and the building up of the administrative machine. This included the topographical survey mapping of the Sudan to facilitate the pacification of the country and the stabilization of the civil administration. The second was to increase food production over greater areas by every available means. At that time gum arabic remained the only cash crop of significance for export so that from the beginning the economy of the Sudan has turned largely on the fortunes of a single crop.

To render the efforts to increase food production effective medical and sanitary services were greatly improved and extended, thereby bringing into the range of development whole territories previously barely inhabited. It is hard to realize the transformation brought about between 1918 and 1939 through the application of the discoveries of medical research. By the use of sulpha drugs, antimalarials, antibiotics, vaccines and insecticides the Sudan Medical Service succeeded in securing the conditions that made possible

the projected development of the south. Some idea of the prevailing state of public health in the south before this salutary transformation took place may be gained from a Government regulation, in force at the time, which allowed resident service south of the tenth parallel to rank as one third more for pensionable service.

The basic physical foundations having been consolidated, the next requirement was to find a suitable cash crop adapted to soil and climatic conditions in accessible areas. Egyptian long staple irrigated cotton proved to be the answer and has so far held its place against all challengers. A great deal of pioneer agricultural research and experiment was necessary before this position was reached about 1912. Plans were then implemented for extensive development in the fertile clay plain known as the Gezira which lies between the Blue and White Niles. This major project required irrigation works of the first order and so the Sennar Dam and its associated system of canals came into being. The outbreak of the 1914–18 war proved a setback to the progress of the scheme, but by 1926 an area of 300,000 feddans* was commanded by the reservoir level. Today, the Gezira irrigation scheme comprises one million feddans in all. This well planned enterprise in agricultural research and development has proved over the years to be economically the very heart of the country. Developments for the production of American Upland cotton, using rainfall in the Nuba Mountains (Kordofan Province), were also successful in the 1930s. Progress by the use of the ' hafir '† was a feature of the last decade.

In the authors' view it was this balanced and realistic attitude of common sense in providing the material conditions, which permitted further logical development along economic lines, that characterized the general agricultural policy of the Sudan at the time of its most rapid development. It was in harmony with the trends of colonial development in British territories overseas and in its place and time served the country well and avoided such tragic fiascos as the Ground-nut Scheme in East Africa. It did not indulge in undue theorizing but contented itself by getting on with the job as means and opportunity allowed.

The responsible authorities worked in the faith that the betterment of Man's estate in a changing world must follow inevitably once the economic foundations had been well and truly laid. It is the authors' view that only after material needs have been satisfied can spiritual values have a chance to emerge. The realization of this principle forms the basis of all true missionary work among primitive communities. In spite of this, a close consideration of much of the thought and writing of the post-1945 period would lead one to the conclusion that the reverse of this process is expected to operate, with results that can easily be foreseen. Indeed one is led to ponder whether this may not be one of the things that is wrong with the philosophy behind the Zande Scheme.

THE ZANDE SCHEME

The Zande Scheme merits attention not only for this reason but because it represents the first large-scale development and research project of this

* 1 Feddan = 1·038 acre.
† *Hafir*, pl. *hafirat*, is the Arabic word for a pit or a reservoir dug to collect rain water.

problem area of the south. The Scheme came into being as a result of an official memorandum by TOTHILL (1943) entitled ' A suggested experiment for the social emergence of indigenous races in remote areas '. The scheme was formulated in 1943, approved in principle by Government in 1944, and implemented under the Equatoria Projects Board in 1945. As we are mainly concerned with principles it is not necessary to go into details here and full accounts of the Zande Scheme up to 1954 have been published elsewhere (FERGUSON, 1949; MCCALL and FERGUSON, 1951; MCCALL and LEA-WILSON, 1954; FERGUSON, 1954; LEITCH, 1956). In his proposals Tothill broke away from the so-called ' coastal belt ' policy, which he considered inadequate for regions such as Zandeland, and postulated the necessity for a distinct ' remote areas ' agricultural policy for central Africa. The basic principle of the Scheme was self-sufficiency, whereby the primary agricultural products of Zandeland would be processed on the spot, manufactured into needed consumer goods, and the whole economy thus rendered self-supporting by the drastic elimination of export and import costs. However, in Tothill's proposals it was emphasized that economic expansion by agricultural development was only a means to an end and the great objective to work for in his view was ' nothing less than the complete social emergence and economic stability of the Zande people '.

The economic foundation of the project is the introduced cotton industry, which provides for the growing, ginning, spinning and weaving of cotton within the area, the surplus cloth being exported to other parts of the Sudan. To implement the industrial side of the scheme a modern spinning and weaving mill, with power house using charcoal as the primary source of power, sawmills, and ancillary plant for seed-crushing and soap-making together with the necessary stores and workshops, were erected at Nzara, 16 miles west of Yambio. This has now developed into the industrial centre of the south. The whole scheme up-to-date has involved the outlay of at least one million pounds (Egyptian*) of public funds and a further appropriation of £E500,000 for capital outlay. A jaggery sugar project on a small scale was established at Sakure, 27 miles southwest of Yambio in the Nduku valley. About 150 feddans have been planted with a Java variety of sugar cane (POJ.27/25). The agricultural policy included the development of crops such as oil palms, coffee and Deccan hemp (kenaf), all on the scale of peasant agriculture. Tothill also envisaged the exploitation of other local resources but the main scheme was confined to the above crops. It was hoped to develop an industry in gunny bags, an essential commodity for the Sudan, but the difficulties and uncertainties proved too great and the project was abandoned. Lastly, Tothill stressed the importance of development by logical and orderly steps; this was all that was possible under the primitive conditions of such a remote area. Nevertheless he insisted on a sufficiently bold policy for the Board to function effectively (FERGUSON, 1954).

The experience of a decade has resulted in a considerable amount of modification of the original scheme in order to meet practical difficulties. The ban on manufactured imports was soon found to be impracticable and

* £E1 (Egypt) is 100 piastres or £1. 0*s.* 6*d.* (Sterling).

was dropped. This enforced decision marked the first departure from the basic principle of self-sufficiency. In effect, it meant that goods locally produced under the Zande Scheme must henceforth compete against imported goods in the open market. Moreover, the repercussions of these unforeseen conditions had an unfortunate reaction on the entire economy of the Zande Scheme. The situation envisaged by Tothill, in which profits arising from the operations of the Equatoria Projects Board would finance the whole Zande Scheme, was thus radically changed. On the agricultural side the organization and supervision of cotton growing in Zandeland proved a heavy responsibility and the preoccupation of the Board's field staff with this problem precluded any rapid advance with the important coffee, oil palm and tobacco projects. Coffee, in particular, might well have been developed more systematically with satisfactory results. A saving of £2 million a year of foreign currency could be effected if the southern Sudan supplied the coffee consumed in the country. The development of these cash crops has at present advanced little beyond the stage of small-scale experimental trials. On the other hand *Citrus* and mangoes have become well established.

ACHIEVEMENTS AND HAZARDS

It has rightly been said that to anyone familiar with Zandeland before the inception of the Zande Scheme the most remarkable feature was the creation of the industrial centre of Nzara, a little bit of Lancashire in the heart of the African bush. Although many of the difficulties which appeared insoluble during the phase of construction have now been overcome and happily forgotten, the engineers and technicians who succeeded in this formidable task in face of the most daunting odds are entitled to high credit. The engineering problems encountered in the construction of factories and the transport and installation of plant in remote and primitive areas must be experienced to be appreciated. It will suffice to state that they are enormous. Almost as great an achievement was the success in turning a sufficient number of Zande tribesmen into reasonably effective operatives to run the shifts in the cotton mill. Some idea of the scale of these operations is gained from the fact that the power station erected at Nzara is the third largest in the Sudan.

However great the technical difficulties to be overcome, there can be little doubt that the principal hazards of the Zande Scheme are sociological and psychological. An anthropological survey has been made of the reactions of the Azande to the social upheaval and systematic uprootings that have virtually turned their barbaric way of life upside down. In the opinion of the authors it is much too early to hazard a guess as to the effects of this, and he would be a bold prophet who could forecast the long-term results of such radical changes on the tribal cohesion of the people (Reining, 1956).

It is perhaps understandable that the early enthusiasm of the promoters of the Scheme blinded them to the quality of the human material with which they had to work. However tough may be the purely material problems, the human problems are likely to be more subtle and unpredictable. No doubt there were sound reasons for the choice of Zandeland as the remote area for this ambitious experiment in social emergence but it is evident that the significance of the human element, in the case of the Azande, was

underestimated. It does not require great experience either of Azande tribesmen or of the Zande area to realize that early assessments of their capabilities as good and industrious agriculturists are unhappily not justified by realities.

It may well be asked, 'How could it be otherwise ?', when the considerations influencing the Zande's choice of cultivable land are understood. The Zande farmer may be ignorant and primitive but he is by no means unintelligent and is knowledgeable to the extent that, from long experience by trial and error, he has arrived at some reasonable ideas as to what constitutes a fertile soil and what does not. Nevertheless, an unfavourable reply to a question put to the oracle may lead him to abandon without hesitation land of high fertility, which is by no means abundant. Or again, if the wife of a farmer dies, it is in accordance with tribal custom that he may not again go near the house occupied by that wife or cultivate her particular garden. Indeed the death of a wife may quite easily lead a Zande cultivator to abandon altogether that particular homestead. The fact that the Zande tribe is so infiltrated with beliefs in oracles, spirits and magic, all hallowed by tradition and custom, acts as a very real obstacle to their advancement as agriculturalists. For these and other reasons the problem of replacing shifting agriculture by a more settled system of farming is difficult. The fact that the Zande himself is but an indifferent farmer, not given to energetic enterprises, and caring little for the urgencies of life, does not help the problem. It was left to an observant layman to give a penetrating picture of the Azande when he wrote: 'The Azande, like many other Africans, love leisure more than possessions. Their traditional wants are small, and can be satisfied with a minimum of effort, despite the intrinsic poverty of their territory. A little maize and fruit to eat; a hut, wives and children; time to sit in the sun, or doze in the shade—these to the Azande are the real sweets of life' (MANN, 1954).

ZANDE PSYCHOLOGY

The psychology of the Zande farmer is again brought out in his attitude towards the cash crop, cotton, the key project of the scheme. From the outset the Zande farmer has never regarded it as his own crop but as the *Hakuma* crop, i.e. to be grown for the benefit of the Government. To understand a simple people it is necessary to live with them and know their language, history, customs, and aspirations; and to interpret the data thus acquired first-hand demands a good deal of experience and penetration.

The first reactions of the Azande to the scheme have been described as a 'childish delight . . . in the novelty of these new "games"' (MCCALL and LEA-WILSON, 1954). Such impressions may only be superficial and may afford no clue to their real thinking, since their standards of values, methods of judgement and everyday notions are utterly different from those of the European or American. But this much can be said with some degree of confidence. The Zande tribesman could not fully understand the aims and objects of the scheme but he started out with faith in the new order of things, accepted cotton growing with enthusiasm, and cooperated well in the upset involved in the large-scale resettlement. There can be little doubt that at its inception the Zande Scheme supplied an interest and gave a fresh impetus to life to a conquering tribe now deprived of their warlike ambitions. The

fact that their first enthusiasm wore thin, when the realities of hard work and small returns from the stubborn soil became apparent, is explained by the increasing disappointment that set in. To this must be added the occurrence of a poor crop in the 1952–53 season (*vide Table 1*), never unexpected in this region, and a change for the worse in the economic situation. These factors had the effect of adding disenchantment, if not disillusionment, to the scene. *Table 1* summarizes the latest available data on the total area and the production of seed cotton since the 1947–48 season. *Table 2* gives the respective yields per feddan since the commencement of the scheme, with comparative average yields for control plots, not receiving special treatments, on first and second year land at the Yambio Experimental Farm. Acknowledgement is due to the Equatoria Projects Board (E.P.B.) who kindly supplied much of this information. Low district averages were caused by bad crop husbandry (ANTHONY and WILLIMOTT, 1955). The principal factors were bad sowing, inadequate weeding and poor picking, reflecting the lack of enthusiasm of the cultivator.

Table 1. Areas and total production of seed cotton

Season	Area (feddans)*		Total	Small Kantars†
	Zande	Maridi		
1947–48	5,400	3,500	8,900	40,000
1948–49	6,300	3,300	9,600	34,000
1949–50	8,900	3,700	12,600	48,000
1950–51	12,000	4,900	16,900	81,000
1951–52	15,500	7,200	22,700	79,000
1952–53	15,100	7,700	22,800	42,300
1953–54	12,300	5,200	17,500	63,700
1954–55	8,500	7,200	15,700	27,000
1955–56	—	—	15,800	50,000*

Table 2. Yields of seed cotton (Small kantars per feddan)

Season	Zande	Maridi	Whole scheme	Yambio Experimental Farm
1945–46	4·8	3·0	—	
1946–47	5·4	3·5	—	
1947–48	5·4	3·7	4·5	
1948–49	3·6	3·1	3·5	
1949–50	4·2	2·9	3·8	8.4
1950–51	5·0	4·4	4·8	9·0
1951–52	3·2	4·1	3·5	5·3
1952–53	2·0	1·6	1·9	9·6
1953–54	3·7	3·2	3·6	7·9
1954–55	2·4	0·8	1·7	9·3
1955–56	—	—	3·2*	—

* E.P.B. estimate. † 1 small kantar = 100 lb approximately.

DISCUSSION

From this review of more than a decade of work on the Zande Scheme it is seen that substantial progress has been made and some lasting results achieved in this first large-scale development plan for the southwest Sudan.

Nevertheless, it would be idle to imagine that all is well with the Zande Scheme today. Already we have seen that in spite of its good intentions three major miscalculations have revealed themselves in the economy, agriculture and psychology of its working. Tothill stipulated a period of 30 years before results could be expected and it has often been emphasized that earlier comment and opinion would be premature and undesirable. But it is clear that the scheme was expected to produce results much earlier, and it was intended to apply the experience gained to other areas of the Sudan and to countries of central Africa faced with similar problems (Ferguson, 1954). The 30-year span is well enough but it should not be interpreted as excluding criticism or discouraging suggestions on progress made to date. Only by constructive criticism can the Zande Scheme be revitalized to meet the changing conditions and to play its vital role in the realization of a happier future for these primitive people. If development is to continue in the southern provinces the Zande Scheme must go on, with the necessary modifications incorporated and a more realistic attitude adopted towards the present day problems it has to solve.

SUMMARY

(1) Many factors have contributed to render the southern Sudan one of the most intractable regions of the tropics. Consequently agricultural development has proceeded there at a slower pace than that of the northern provinces. Contributory causes were the inaccessibility of the south, the need to initiate development of the main crop (cotton) in the more favourable conditions of the north, the economic depression of 1929–32, and the outbreak of the 1939–45 war. One of the first steps taken by Administration to remedy this state of affairs was the decision to undertake an ecological survey of the southern Sudan.

(2) The general agricultural policy of the Condominium Administration is considered. After the establishment of law and order, steps were taken to increase food production and extend medical and sanitary services. Emphasis was laid on the establishment of a sound economic foundation, which could provide an effective background for social emergence and the full expression of intellectual and spiritual values. A balanced and realistic attitude of common sense, free from undue theorizing, characterized the general agricultural policy of the Sudan at that time.

(3) The Zande Scheme was the first major agricultural development project in the southern Sudan. The guiding principle was self-sufficiency and the economic foundation of the project was the introduced cotton industry. To implement the industrial side of the scheme a modern spinning and weaving mill was established at Nzara, which has now developed into the industrial centre of the south.

(4) The experience of more than a decade has produced substantial progress and results of lasting value. Nevertheless, a number of economic, agricultural and psychological miscalculations have revealed themselves.

(5) Azande psychology is examined in detail. The need for a complete understanding of tribal customs and aspirations if an acceptable scheme of development is to be evolved is obvious. Difficulties encountered in persuading the Azande to utilize effectively their most fertile soils are described,

and some account is given of their reaction to the introduction of cash crops.

(6) The declining enthusiasm of the Zande farmer is reflected in the results summarized in two tables in which yields from native holdings are compared with those obtained on control plots at the Yambio Experimental Farm.

(7) It is essential for future development in the southwest Sudan that the Zande scheme should continue, but for lasting success modifications must be made and a more realistic attitude to present day problems adopted. Sociological changes in primitive peoples exposed to fundamental changes in their way of life may pose difficult problems, and it is clear that social enlightenment can only follow on substantial development in agricultural practice.

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REFERENCES

ANDREWS, F. W. (1948). *Agriculture in the Sudan* (Ed. J. D. TOTHILL), pp 34 and 46 to 49. Oxford University Press, London

ANTHONY, K. R. M. and WILLIMOTT, S. G. (1955). *Annual Report*, Agronomy Section, Yambio Experimental Farm, Research Division, Ministry of Agriculture, Sudan

FERGUSON, H. (1949). *Emp. Cott. Gr. Rev.* **26** (2)

— (1954). 'The Zande Scheme.' *Bull. No. 14.* Ministry of Agriculture, Sudan Government, Khartoum

LEITCH, T. A. T. (1956). 'What Future for Zande ?' *New Commonwealth*, May

MCCALL, A. G. and FERGUSON, H. (1951). 'The Zande Scheme in the Anglo-Egyptian Sudan.' *World Crops*, **3**, 23

— and LEA-WILSON, K. L. (1954). 'Some notes on Zandeland' from *Food and Society in the Sudan.* Philosophical Society of the Sudan, Khartoum, December

MANN, A. (1954). *Where God Laughed*, Chap. XIV. London

MYERS, J. G. (1937-42) *Plant Ecological Survey of Equatoria Province*, Books 1–7. Khartoum (unpublished)

REINING, C. (1956). *D. Phil. Thesis*, University of Oxford (unpublished)

TOTHILL, J. D. (1943). *A Suggested Experiment for the Social Emergence of Indigenous Races in Remote Areas* (unpublished). Ministry of Agriculture, Khartoum

— (1948a). *Agriculture in the Sudan* (Ed. J. D. TOTHILL), pp 136 and 587. Oxford University Press, London

— (1948b). *Agriculture in the Sudan* (Ed. J. D. TOTHILL), p 3. Oxford University Press, London

Experiments on Cocoa Drying and Fermentation in West Africa

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An account is given of experiments on cocoa drying and fermentation carried out at the West African Cocoa Research Institute, Tafo, Ghana, during October, November and December 1956, which were an extension of the work on fermentation, by the present authors (Howat *et al.*, 1957), in Ghana, during the main crop seasons of 1954 and 1955.

The major interest in the two previous investigations was cocoa fermentation, rather than drying, which was wholly by the heat of the sun in the traditional West African manner, but the 1956 investigation was mainly concerned with the artificial drying of cocoa beans.

In some cocoa growing areas, such as those in Ghana for example, where the rainfall is not excessive, and the number of bright sunny days considerable, it is possible to dry fermented cocoa beans in the sun in 6 to 10 days. The beans are dried on the ground*, or on trays, which must be covered when rain falls, or on drying wagons, i.e. large trays fitted with wheels which run on rails, so that they can be run back under a shelter, and these shelters can be kept to reasonable dimensions if the rails are so arranged that one wagon will run above another. An alternative protection is a moveable roof, running on rails, so that it can be drawn over the beans lying on a fixed floor. Such methods have been in use in many places—West Indies, Central and South America, Indonesia, etc.

In other areas, less fortunate in their climatic conditions, it is necessary to use artificial heat to dry the beans, for to rely on the sun alone where the rain and cloud are excessive leads to the serious risk of mould, and mould in cocoa is most undesirable. It is one of the worst defects in commercial cocoa beans, for the unpleasant flavour it introduces persists throughout the process of manufacture; the fibrous portion of the bean is unusable and the fat, even after refining, has a restricted use.

METHOD OF DRYING BEANS BY ARTIFICIAL HEAT

Cocoa dryers have been in general use for over 50 years and there is a record (Hart, 1911) that they were discussed in Trinidad as early as 1865. The types have been numerous and various and the survey below is confined to those of greater importance which can be found working at the present time.

In the simpler types of artificial dryer, beans are dried by heating the drying floor below by hot air. Pipes are installed within the air space beneath the floor and through them circulate water from a boiler or the hot products of

* A method which is not recommended as the beans can be easily contaminated by animal droppings and other dirt.

combustion from a wood fire or burning oil jet. The drying floor may permit the passage of hot air through the beans (Martin dryer), and the addition of a fan (Vis dryer) to draw off the moist air is an advance. The roof of the Martin dryer is sometimes constructed so that it can be run back in times of fine sunny weather and the drying process hastened by direct heat from the sun.

In the Cameroons dryer, the space between the flue pipes and dryer floor is filled with earth, and an uneven temperature distribution results, making more frequent raking over of the beans necessary with this type of dryer. Faulty construction is common, and smoke may come into contact with the beans when off flavours result.

In the dryers of the stationary tray type (for example, the ' Chula ', below) a blast of indirectly heated air is forced through a stack of metal trays, with wire mesh bottoms, and charged with wet fermented beans; if the stack contains many trays it is advisable to interchange their positions during drying. When the desired output of dry beans is very large, and tray loading and unloading becomes laborious, it is an advantage to use a continuous dryer such as the Buttner. An endless row of trays passes spirally down a vertical cylinder through which hot air is circulated.

The Gordon and McKinnon dryers have achieved a large measure of popularity; a large cylinder rotates slowly about a horizontal axis, along which hot air flows and escapes into compartments containing the beans. The rotation of the cylinder leads to the rubbing of the beans against each other and, when dry, they exhibit the polished appearance prized by some cocoa buyers. The testa is also rather thinner on account of the abrasive action of one bean on another and there is an increased incidence of broken beans.

For success it is essential with all the dryers outlined above that no chance be given for the beans to be exposed to the products of combustion or taint will inevitably result.

THE PROBLEM

Although many different types of dryer have been in use for some time, we could find no published account of a careful investigation into the principles of artificial drying—the limits of time and temperature consistent with producing beans of good quality.

At the end of fermentation, during which important chemical changes occur, necessary for good chocolate flavour, the moisture content of the whole bean is around 56 per cent and in drying these chemical reactions continue, while the moisture content is reduced to 5 to 8 per cent. If lower, the bean becomes excessively brittle, and if higher, mould will develop. The moisture content of cocoa is sensitive to changes in atmospheric humidity and tends to attain equilibrium with its environment, so even if it is reduced to say, 4 per cent, it will increase subsequently by absorption from the atmosphere. Most of the chemical reactions involve enzyme systems, so while it is desirable to employ a high temperature to ensure rapid removal of water, it must not be too high and lead to the inactivation of these enzyme systems before they have played their part in the chemical reactions, without which good chocolate flavour will not be obtained. In addition, the enzyme

systems must not be inactivated by too early dehydration. The sun drying of cocoa beans usually occupies a period of at least one week, whereas with a dryer this can be reduced to one day or less. It was reasonable to suppose that some modification of the usual fermentation process would be an advantage, and this formed part of the programme of experimental work carried out at the West African Cocoa Research Institute.

EQUIPMENT

(a) *The dryer*

The oil-fired 'Chula' cocoa dryer, a prototype model (*Figures 1* and *2*) manufactured by the Tyneside Foundry and Engineering Company, dries the wet fermented beans in stationary trays by hot air. A 3·25 h.p. Ruston and Hornsby diesel engine drives a fan, which draws air over twin flue pipes and a firebox, and then blows it through the charge of beans. The firebox is heated by a Swirlamiser oil jet, the oil being vaporized by air from a small compressor (4 to 6 lb in^2) also driven from the engine (the engine, fan and compressor contain the only moving parts). From the firebox, the hot gases pass along the twin flue pipes, mentioned above, to the smokebox and chimney and so to atmosphere. It should be noted that the air which dries the beans is indirectly heated by the burning oil and cannot be contaminated by the products of combustion.

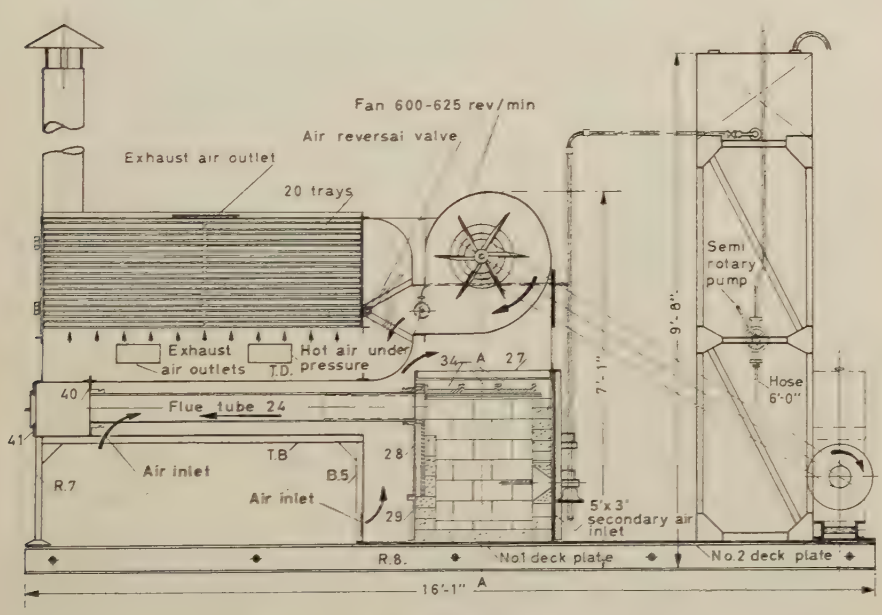

Figure 1. Chula dryer, part sectional elevation

A flame failure thermostat and a temperature control thermostat of the air leak type are fitted, the presence of which, in view of the general design of the dryer, mean that it can be left to run unattended when necessary. The position of the temperature control thermostat in the hot air trunk

between the fan and drying chamber enables the temperature of the hot air blast to be controlled at a chosen value, $\pm 2°C$.

After fermentation the wet beans are placed in 20 tinned steel trays with wire mesh bottoms, standing in pairs, one above the other, on racks in the

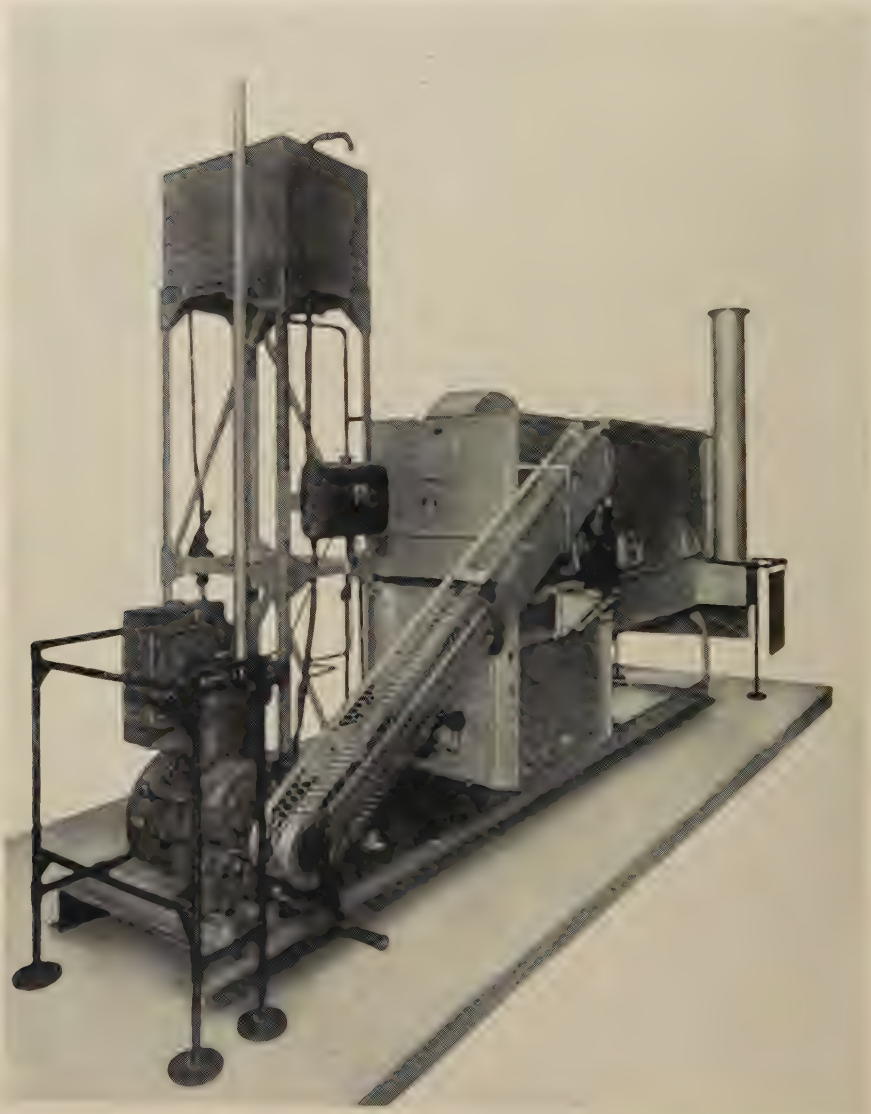

Figure 2. Chula dryer

drying chamber (*Figure 3*). The blast of hot air which enters the chamber from below, and beneath the trays, must pass through them before escaping to atmosphere.

The maximum capacity of each tray is about 43 lb of wet fermented beans, making each complete charge a maximum of 860 lb. This weight corresponds to about 1020 lb of wet unfermented beans (there is a loss of weight of 16 per cent during fermentation) which results in 450 lb dry cocoa beans (moisture content about 6 per cent).

Figure 3. Unloading the Chula dryer at Tafo

(b) *Fermentation boxes*

The fermentation boxes, either 3 ft square × 2 ft 6 in. deep or 4 ft square × 2 ft 6 in. deep were constructed of wood (*Chlorophora excelsa*) 1 in. thick mounted 1 ft above ground on a wooden framework. About 50 holes $\frac{3}{8}$ in. in diameter were bored through the bottom at regularly spaced intervals to allow sweatings to drain away. A charge of 1200 lb wet, unfermented beans fill a 3 ft square box to a depth of 27 in. and a 4 ft square box to a depth of 15 in. Neither the sides nor the bottom of the box were lined with plantain leaves, but a thick layer was placed on the top of the beans.

(c) *Trays for sun drying*

The drying trays can be seen in the background of *Figure 3* and are self-explanatory.

MATERIALS AND METHODS

(a) *Cocoa pods*

The cocoa pods of the Amelonado type were drawn from the plantation of the West African Cocoa Research Institute and the beans from 25 tons of pods were used. Usually about two days elapsed between harvesting and breaking.

(b) *Drying the beans*

Beans were dried either in the Chula dryer (see below) or on trays in the sun which could be covered quickly in the event of rain. While sun drying was in progress the beans were frequently raked and picked over, the thickness of the drying layer being kept at about 2 in.

(c) *Mixing the fermenting beans*

To mix the beans during fermentation, they were transferred quickly to another box with the aid of a scoop or basket, so that with two concurrent fermentations it is useful to have a set of three boxes.

(d) pH *measurements*

20 beans from the fermentation box were wiped with filter paper, and after removing the testas and mixing, 10 g of broken cotyledons were weighed and transferred to a mortar. Grinding was continued with the occasional addition of water up to 85 ml at room temperature until the particles were fine. The pH of the suspension was taken to be that of the cotyledons.

(e) *Moisture determinations*

Determinations of moisture were again made on the cotyledon only—about 20 beans were taken and after removal of the pulp and testas the cotyledons were quickly broken up in a small mortar, 6 or 7 g being dried at 100°C for 2 hours.

(f) *Chocolate for tasting*

Chocolate made up at Bournville from each sample of beans by a carefully standardized process was tasted by a panel composed of experienced persons against chocolate (referred to below as the control chocolate) made by the same process from good quality West African beans. The identity of the chocolate samples was not revealed to the panel until the tasting test was complete.

(g) *Output of the dryer*

When describing the capacity of the dryer it is important to be careful of the terms. In fermentation there is a loss in weight, considering the beans together with their adhering pulp. Starting with 1000 lb of wet unfermented beans, fermentation ends with only 840 lb of wet fermented beans. It avoids confusion to compare dryers on the basis of their output of dry cocoa beans, rather than on their input.

EXPERIMENTAL WORK

The object of the work with the Chula dryer was to determine the operating conditions giving the shortest drying period and the least fuel consumption consistent with three objectives:

(*1*) The beans must make up into good chocolate.

(*2*) The beans must not be brittle—with broken shells the chance of infestation is increased and broken cotyledons can lead to losses during factory processing.

(*3*) The beans must be of good marketable appearance and preferably similar to those dried in the sun.

In determining these conditions the general principles of artificial drying, which would be of application to other dryers, would be established.

Variables

In the hot air dryer with stationary trays there are three variables—temperature of the air, the air velocity and the depth of the beans in each tray.

Temperature—At first sight, increase of temperature would be expected to result automatically in reduction of drying time, but with some commodities there is the phenomenon of 'case hardening'. Too high an initial air temperature affects the outer layers and impedes the further diffusion of water from the interior to the outer surface, where evaporation takes place. No published information was available to show how the fermented cocoa bean would behave, and temperatures in the range 60° to 80°C were employed.

Air velocity—No instrument was available for measuring the velocity of the air in the dryer, but it would increase with increase of fan speed, without necessarily being proportional to it. Fan speed was varied and recorded as being a guide to air velocity.

Bean depth—Increase of the bean depth in each tray would result in slower drying and increased fuel consumption, though with a larger output, and so may or may not be advantageous.

The fermentation procedure, as well as the dryer operating conditions, is capable of variation and experiments were carried out with different depths of beans in the fermentation box and with different periods of fermentation. A portion of the beans from each fermentation was dried in the sun in the traditional (West African) manner, and the remainder in the dryer, the quantity in each case being large enough for processing, on the factory scale, at Bournville. A careful record was kept of the fuel consumed by the engine and the burner, so that, after the processing and tasting of the chocolate from the various experiments, the operating conditions producing the most desirable beans at the lowest cost could be given. The complete list of dryer experiments is given in *Table 1*.

Experiments 1 to 4

The first four experiments demonstrated clearly that the machine would dry 700 to 800 lb wet fermented beans in 15 to 20 hours and produced beans of satisfactory flavour and appearance without brittleness.

A device fitted to the dryer enabled the hot air blast to be directed downwards through the charge of beans in the chamber, rather than upwards, at will. The designer intended that it would make it unnecessary to change the position of the trays in the dryer during a run, but in this he was unsuccessful. To secure beans of uniform moisture content it was found better to keep the air blast always directed upwards through the beans and to interchange the trays twice during the run—at the end of the fourth and eighth hours. Each interchange required two men for about 10 minutes.

During drying there is a slight variation in the rate of drying within a given tray and a rather greater variation from one tray to another. The double interchange of trays is necessary because of this latter variation

Table 1

	Fermentation			*Dryer*							*Sun-drying*		
Experiment	*Days* (*e*)	*Depth* (*in.*)	*Final* pH *cotyledon*	*Charge* (*lb*)	*Fan speed rev/min*	*Tempera-ture* (°*C*)	*Time* (*h*)	*Moisture* %	*Final* pH *cotyledon*	*Oil* (*gal*) (*d*)	*Moisture* %	*Final* pH *cotyledon*	*Time* (*days*)
1						80							
2						70							
3						70							
4						80							
6	6	27	4·8	760 (*f*)	560	80	14	7·0±1·4 (*c*)	4.8	17 (*k*)	5·8	5·1	10
7	7	27	4·7	760	560	80	13·5	5·8±0·7	4·5	15 (*k*)	5·6	5·1	8
9	6	27	4·7	760	560	70	20	6·6±1·2	4·8	24 (*l*)	6·0	4·9	6
11	7	27	4·9	760	560	70	20	7·1±0·7	4·8	20 (*l*)	6·4	5·1	6
12	6	27	4·6	760	560	60	24	7·2±0·9	4·8	21	6·8	5·1	4
13	6	27	4·6	760	690	80	13	9·7±1·0	4·8	17 (*k*)	5·6	5·3	7
14	6	27	4·8	860 (*g*)	560	80	16·5	6·2±0·8	5·0	23	6·4	5·0	8
16	6	27	4·8	760	560	80/60 (*i*)	21	7·1±1·1	4·7	22	4·6	5·2	8
19	6	15	4·7	760	560	80	15·5	6·2±1·2	4·7	20 (*k*)	6·1	5·0	6
21	7	27	4·9	760	560	60/80 (*j*)	19·5	4·5±0·9	4·8	22	5·6	5·0	6
23 (*h*)	6	27	4·9	760	560	70	21	4·7±0·8	5·1	23 (*l*)	4·9	5·8	7
24	8	15	5·1	760	560	80	15	4·4±0·6	(*b*)	18 (*k*)	(*a*)	(*a*)	(*a*)
26	8	15	5·0	860 (*g*)	560	80	14	5·6±1·1	5·2	16	(*a*)	(*a*)	(*a*)
27	6	15	5·0	760	560	80	14	5·0±0·6	4·8	19 (*k*)	(*a*)	(*a*)	(*a*)

(*a*) Not available
(*b*) No record
(*c*) Trays only interchanged once
(*d*) Excluding warm-up period
(*e*) Mixing after 2 days, 4 days, 6 days
(*f*) 38 lb wet fermented beans per tray
(*g*) 43 lb wet fermented beans per tray
(*h*) Mixed fermentation (see text)
(*i*) Temperature lowered after 8 hours
(*j*) Temperature raised after 8 hours
(*k*) Mean fuel consumption 6 runs at 80°C, 18±1 gal
(*l*) Mean fuel consumption 3 runs at 70°C, 23±1 gal

and by the end of the drying period the moisture content of the beans, in the different parts of the dryer, is satisfactorily uniform.

Experiments 6 to 26

Experiments 6 to 26, which included some repeat runs, comprised a systematic attempt to cover the various combinations of operating conditions of the dryer and fermentation procedures.

Experiment 23

Experiment 23 was designed with the idea of a central fermentary in mind and utilized beans from a special box fermentation. A 6-day fermentation with turnings after 2 and after 4 days was begun with a mixed charge of beans. Some had stood exposed to the weather for 1 or 2 days, while others had been in baskets and sacks for similar times. This is the sort of history which it is anticipated a charge of beans would have in a central fermentary, to which wet unfermented beans were brought from farmers.

RESULTS

Examination of *Table 1* shows that many different dryer conditions and fermentation procedures have been investigated.

Quality of the beans

The beans from the dryer have a good plump appearance, a rather brighter colour than those dried in the sun and a brown cut. Commercial defects are absent but the beans are slightly more brittle than the corresponding sun-dried samples.

The panel, which tasted all the fully processed chocolate samples against the control from good quality West African beans found:

(*1*) In some comparisons the control chocolate was preferred, and in others the experimental sample, but all fell within the acceptable West African flavour range.

(*2*) There was little to choose between sun- or machine-dried beans from a given fermentation.

(*3*) Though there were differences between the various machine-dried samples they were not of sufficient significance to warrant recommending one method of operation of the dryer in preference to another on the grounds of flavour. It is therefore possible to dry beans in an air blast at a temperature* of 80°C, and in a time of about 14 hours, without detriment to the subsequent chocolate flavour.

(*4*) A fermentation time as long as 8 days is unnecessary; it is in fact undesirable.

(*5*) It is immaterial whether a shallow or a deep fermentation box is employed within the limits set out in the report.

(*6*) The result of experiment 23 shows that beans exposed to the weather or kept in bags or baskets for one or two days before a 6-day fermentation do suffer some slight deterioration in flavour.

As has been stated, from a given fermentation there is only a slight

* Since water has high specific and latent heats the temperature of the bean will approach that of the air blast during the latter portion of the drying period only.

difference between the flavour of chocolate made from beans dried in the sun over a period of about 7 days and of those dried in the machine in 14 hours, after complete factory processing which includes conching. A greater difference is found, however, if the chocolate is sampled before the operation of conching (which, as is well known, removes certain volatile flavours) when the machine-dried beans have a fairly strong 'fruity' or 'estery' flavour, present only to a slight extent in the sun-dried beans. The phenomenon has been related to the volatile acidity of the dry, fermented bean and is currently being investigated in the Bournville laboratories.

pH *determinations*

Generally, the cotyledons of sun-dried beans have a higher pH value than those of machine-dried beans, but the more significant acidity seems to be the volatile acidity (above) which is being studied.

Operating conditions

The results of the variations in operating conditions can be summarized as follows:

(*1*) Drying at a temperature of 80°C is the most economical in fuel and running time—the mean of 6 runs shows a consumption of 18 ± 1 gallons of fuel and a time of about 15 hours.

(*2*) At a temperature of 70°C the data for 3 runs are 23 ± 1 gallons of fuel, and about 22 hours, respectively.

(*3*) Experiments 16 and 21 considered together demonstrate the absence of a case-hardening effect and of any advantage in altering the air temperature during a run.

(*4*) Experiment 13 shows that nothing was gained by running at a slightly higher fan speed (with increased air velocity).

(*5*) The results from experiments 14 and 26 show that there is an advantage in increasing the charge of wet beans from 38 lb to 43 lb per tray.

(*6*) Variations in the fermentation procedure have no significant effect on either drying time or fuel consumption.

Operating costs

Since the cost of labour and fuel oil varies considerably from one area to another, little purpose would be served in calculating our running costs, though from the above summary it is easy to do so for any particular cocoa-growing area, bearing in mind the labour requirements. It is safe to run the dryer unattended but a man—with the mechanical ability of a lorry driver, say—should be available from time to time to check lubricating oil level, etc. The operations of loading, interchanging and unloading the trays call for two labourers for about ten minutes on each occasion.

CONCLUSIONS

(*1*) The previous seasons' findings, that cocoa beans can be successfully fermented in 6 days (with turning after 2 days and 4 days) in a box 3 ft square are confirmed, and extended, with charges as great as 1200 lb. A shallower box 4 ft square with the same charge is equally suitable.

(*2*) We found no advantage by increasing the fermentation time to 7 days, even when the beans are dried artificially rather than by the heat of the sun, and an 8-day fermentation results in a less satisfactory flavour. The commonly held belief that fermentation times should necessarily be increased when the beans are to be artificially dried is thus not supported by these experiments.

(*3*) Delays of 48 hours between the removal of the beans from the pod, and the beginning of a 6-day fermentation, do lead to a deterioration in the subsequent chocolate flavour.

(*4*) Beans of good quality (judged on appearance and by the chocolate flavour after factory processing) are produced by employing drying temperatures as high as 80°C with a consequent drying time as short as 14 hours. These conditions would be applicable to all dryers.

(*5*) Chocolate from artifically dried beans has an 'estery' or 'fruity' flavour, if tasted before the conching stage of factory processing, a flavour which has been associated with an enhanced volatile acidity of the dried bean.

SUMMARY

In some cocoa-growing areas it is desirable, and in others necessary, to dry the fermented cocoa beans artificially rather than by the heat of the sun. After a brief review of the different types of dryer in use and a statement of the problem of artificial drying, an account follows of experimental work in Ghana with a dryer of the stationary tray type. It has been established that cocoa beans can be dried at high temperature and in a short time without detriment to the subsequent chocolate flavour.

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REFERENCES

T. Law, at a meeting of the Scientific Association of Trinidad. See Hart, J. H. (1911). *Cacao, its Cultivation and Curing*. Duckworth, London

Howat, G. R., Powell, B. D. and Wood, G. A. R. (1957). *J. Sci. Fd Agric.* 8 (2), 65

The Polythene Sheet Method of Rooting Cacao Cuttings

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Since Evans (1951) in Trinidad and Archibald (1953) in West Africa investigated the physiology of rooting, the conditions for successful vegetative propagation of cacao have been known. These workers showed that cacao cuttings require a saturated atmosphere, a certain degree of shade and a rooting medium which can retain moisture while allowing good aeration for the base of the cutting. On the basis of these principles several successful propagators have been devised, but they have tended to be too elaborate and expensive for general use under West African conditions. In most cacao-growing areas of West Africa electricity and piped water are not available so that centrifugal humidifiers or open-bed sprays would be precluded. The cost of a rooted cutting prepared in the standard concrete or Trinidad-type bin varies from 2*s* 6*d* in the Gold Coast to 4*s* 0*d* in Trinidad. Murray (1955) has pointed out that this is comparable with the price of 4 to 5 lb dry cocoa, a sum of money which will be returned many times over in the lifetime of a high yielding clone. Nevertheless, few West African farmers could afford the capital outlay involved and Government subsidies would be necessary. This paper shows that by using a polythene sheet instead of concrete bins or humidifiers, propagation can be simplified, the price greatly reduced and rooting made possible where water is scarce.

The use of polythene in horticulture is not new. Its value lies in its ability to conserve moisture while allowing diffusion of gases. It is tough, chemically inert and is not attacked by fungi. Floor (1954) wrapped cuttings in polythene for increased rooting and also stored plants in it without water for several weeks. Lipp (1953) used polythene for rooting cuttings, storing stratified seeds and for wrapping balled root systems when transplanting.

Archibald (1955) described a method of rooting cacao cuttings in a bed of soil by covering them with a sheet of polythene. 57 per cent rooting resulted with clone S36 compared with 75 per cent usually obtained with this clone in concrete bins. The new method had the advantage, however, of being cheap in materials and labour. Archibald's preliminary experiments were encouraging and suggested that a polythene method might be developed to give results comparable with traditional rooting methods.

EXPERIMENTAL RESULTS

Different methods under polythene sheet

In several experiments using Archibald's technique approximately 60 per cent success was obtained with clone R15, normally one of the most easily rooted types. A bed of top soil from the forest was prepared about

10 ft long, 4 ft across and 6 in. deep. It was well watered and 50 two-leaf cuttings were inserted after the normal quick dip in 0·5 per cent β-indole butyric acid (IBA). The bed was covered with a sheet of polythene, 0·003 in. thick, stretched tightly over the cuttings and weighted down at the edges with stones and bamboo. The polythene was removed every three days and the cuttings sprinkled lightly with water. After four weeks they were transplanted into baskets and hardened in the normal bins. Of the 60 per cent which rooted, 5 per cent failed during hardening as the roots produced in the soil were thick and brittle and broke very easily on transplanting. Hardening was also done *in situ* by removing the polythene sheet for gradually increasing periods of time. This was even less successful, 8 per cent of the rooted cuttings failing to harden; this method was discontinued. To overcome the liability of the roots to break, cuttings were then placed in cardboard pots filled with soil and immersed in the bed, but it was found that after four weeks the pots were soft and difficult to handle, and the roots which emerged through the pots were damaged on transplanting into baskets.

Table 1. Comparison of rooting methods using polythene sheet. 100 cuttings per treatment

Method of rooting	*Method of hardening*	*Rooting*	*Hardening after rooting*
1. *Polythene sheet over bed of soil*	*Transplanted into baskets and placed in hardening bin*	68	95
2. *Polythene sheet over bed of soil*	In situ	59	92
3. *Polythene sheet over bed of soil and cuttings in paper pots*	*Transplanted into baskets and placed in hardening bin*	51	99
4. *Cuttings inserted in soil in baskets and covered with polythene sheets*	*Hardened in the same basket under polythene sheet*	80	100
5. *As 4 but a central core of rooting medium added*	*Hardened in the same basket under polythene sheet*	92	100

In view of the relatively poor results with potting soil as the rooting medium (see *Table 1*) it was decided to use composted palm fibre and sand which is the usual medium in the concrete bins. Transplanting is a costly operation often causing quite high losses, so an attempt was made to carry out the whole operation of rooting and hardening in one basket, as was done by MURRAY (1955) in Trinidad. Cuttings were inserted in baskets containing a core of rooting medium (palm fibre and sand) surrounded by potting soil, covered with polythene sheet and rooting and hardening carried out *in situ*. This method, described in greater detail below, proved highly successful. Comparable results for the various methods tested are given in *Table 1*. The data are means for several experiments, all with Amelonado cuttings. It is clear that method 5 in *Table 1* has given the best results and the rest of this paper deals with experiments designed to improve it further, find its limitations and the exact requirements for success.

Watering

In the first experiments with method 5 (*Table 1*) two pints of water were sprinkled over 50 cuttings every third day. This appeared to make the soil too wet. The amount was reduced to one pint and rooting compared. Both treatments gave 98 per cent rooting and 100 per cent hardening with clone R15. When more water was applied the leaves turned yellow and practically no rooting occurred. More than two pints made the soil obviously waterlogged. Thus between one and two pints of water every third day is sufficient for 50 cuttings. No experiments were done on the lower limit for it is not feasible to distribute much less than a pint per 50 cuttings. The successful level of watering is one seventh of that in a concrete bin (one pint twice a day for 50 cuttings).

Light intensity and leaf area

A light intensity of 15 to 20 per cent of full sunlight over the polythene sheet gave very good rooting in the preliminary experiments, but occasionally a few leaves became scorched and appeared to be inadequately shaded. Light intensity on leaves in a concrete bin is normally about 10 per cent of sunlight. The effect of further shade, reducing the light intensity to about 8 per cent sunlight, was examined. Results are shown in *Table 2*. A comparison was also made between cuttings with the leaves trimmed to about two thirds of their length and untrimmed cuttings as normally used at Tafo. 50 cuttings were used for each treatment.

Table 2. Effect of varying light intensity and leaf area on the rooting of cacao cuttings under polythene. 50 cuttings per treatment

Treatment	*No. of cuttings with roots through basket after 28 days*	*No. of cuttings with buds sprouting after 28 days*	*No. of plants successfully hardened*
15% *light, untrimmed leaves*	22	25	47
15% *light, trimmed leaves*	35	45	49
8% *light, untrimmed leaves*	32	5	45
8% *light, trimmed leaves*	33	23	49

15 per cent light with trimmed leaves gave significantly better rooting than with untrimmed leaves and also gave improved bud sprouting compared with any of the other treatments. This was confirmed in a repeat experiment.

Thickness of polythene sheet

Only 0·003 in. thickness was tried as with the light intensity, leaf area and watering schedule already described results have been very satisfactory. Polythene of this thickness is cheap (4*d* per square foot) and can be used about ten times, that is for one and a half years of continuous use, before it begins to tear.

Recommended method for rooting cacao cuttings under polythene

Two-leaf semi-hardwood cuttings with about one inch of stem are prepared from fan cuttings brought in from the field early in the morning. The leaves should be dark green and hardened, but not old or covered with

algae. The base of the cutting is immersed for 5 seconds in a solution of IBA, prepared by dissolving 0·5 g IBA in 50 ml ethyl alcohol and diluting this stock solution with an equal volume of water before use. A basket, 6 in. in diameter and 7 in. high made from palm midribs, is filled with good forest soil around a central core, about 1 in. in diameter, of rooting medium (50 : 50 sand and composted palm fibre). The basket is well watered and the base of the cutting inserted in the central core. 50 to 100 such baskets are placed together on the ground under about 15 per cent slatted shade, and covered tightly with a sheet of polythene weighted down at the edges (see *Figures 1* and *2*). Usually the baskets can be placed directly on the ground but in dry areas where termites are prevalent they should rest on a bed of stones.

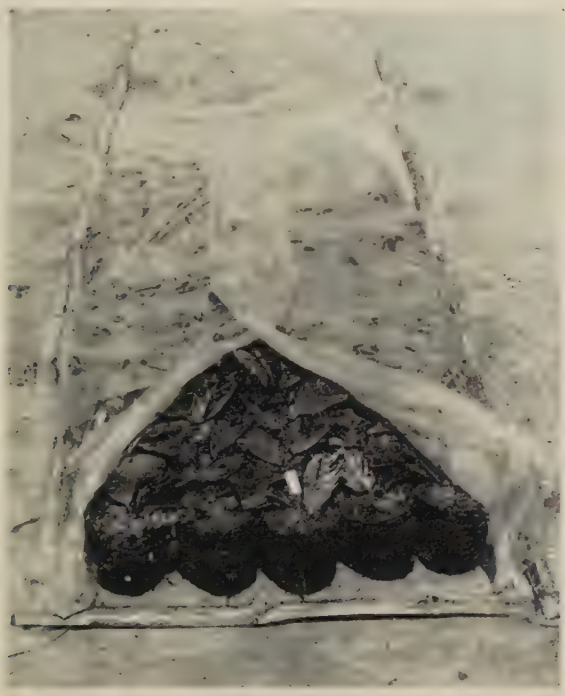

Figure 1. Polythene sheet folded back to show cacao cuttings

Every third day the polythene is removed early in the morning and the cuttings watered lightly with about one pint for every 50 cuttings. No other attention is required until the appearance of roots after about four weeks, when hardening can begin. It is essential not to delay hardening after roots have appeared as they die back during hardening and growth of the cutting may be checked. Hardening is done by stages : during the first week the sheet is removed from 6.30 a.m. to 10 a.m. and this is increased to 11 a.m. and 12 noon in the second and third weeks respectively. The cuttings can safely be removed to a shaded nursery after the third week, before being planted in the field.

Figure 2. Banks of cacao cuttings under polythene

DISCUSSION

Although several techniques for rooting cacao cuttings have been published, the method described above has the advantages of being cheaper, simpler and more efficient than any previous method. Its simplicity makes it ideal for unskilled people, who would find the concrete bin method too difficult. The hardiness of cuttings rooted under polythene is greater than with any of the alternative means of propagation so that there is not the same need for close control over the environment. It may be that in the bins the cuttings are under almost marginal conditions while in individual baskets under polythene the cuttings are in nearly perfect surroundings and can tolerate greater external changes. For example, in the bins frequent attention is needed to keep the atmosphere saturated, while with polythene drops of moisture are always visible on the underside of the sheet. With individual baskets, good drainage and aeration are more easily achieved than in the bins.

Transplanting from the bins into baskets is always a delicate job and unskilled people can cause serious loss of planting material through bad potting. The polythene method eliminates this hazard and at the same time economizes on labour.

Apart from the ease of the new method, it is more effective than using concrete bins. With clone R15, rooting in bins gives about 75 per cent of cuttings successfully hardened while almost 100 per cent success can be achieved under polythene. Clones which normally root poorly also give better results under polythene. Selection T17 usually gives about 30 per cent rooting and this can be raised to over 70 per cent with polythene. Buds tend to sprout more rapidly under polythene than in bins and this early advantage is retained all the way until the plants are ready for the field.

Under Tafo conditions a rooted cutting from under polythene costs about 9*d* compared with 2*s* 6*d* from a concrete bin. This cost includes the price of the basket which is 4*d* and the polythene, which is only $\frac{1}{6}$*d* per cutting. A square foot of polythene costs 4*d* and has a lifetime of ten propagations. The polythene is sometimes torn but can be mended by sticking a piece of polythene over the hole with any commercial adhesive. The 2*s* 6*d* for a bin cutting does not include the capital cost of building a system of concrete bins as they have an almost indefinite life and the cost per cutting will be small. It does, however, cover the cost of repairs to the wooden lids and glass panes of the bins, which can be expensive. Less palm fibre is needed for each cutting under polythene but in the bins it can be re-used and the total amount used is approximately the same. Less water and fewer man hours are required for watering under polythene. Although water itself is not expensive, many areas have little at certain seasons. Once the cuttings are inserted in the baskets and placed under the polythene, the only attention required is a brief watering every third day. Open bed spray systems need careful attention to be successful and concrete bins require close control of light intensity, rooting medium and watering schedule. The polythene method is adaptable to either large scale or very small scale operations and is thus well suited to the needs of the West African cacao farm.

SUMMARY

A method of rooting cacao cuttings in baskets under polythene sheet is described. It is almost 100 per cent successful and is much cheaper than existing methods. It economizes on materials and labour and can be applied to small scale farming or to large plantations.

ACKNOWLEDGEMENTS

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REFERENCES

Archibald, J. F. (1953). Unpublished data

— (1955). *Rep. W. Afr. Cacao Res. Inst.* 76

Evans, H. (1951). 'Investigations on the propagation of Cacao.' *Trop. Agriculture, Trin.* **28,** 147

Floor, J. (1954). 'Planten in plastic.' *Meded. Inst. Vered. Tuinbouwgen.* 55

Lipp, L. F. (1953). 'New methods in plant propagation.' *Arnoldia* **13,** 61

Murray, D. B. (1955). 'Methods of propagation.' *Cocoa Conference, London,* 66

Some Notes on the Influence of Artificial Pollination upon the Production of Oil Palms

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It is often stated that continuous artificial pollination adversely affects the production of the oil palms involved by stimulating the formation of male inflorescences.

The question is not without interest especially to the selectionist as, should this view be correct, it would not be necessary, nor indeed would it be possible, to review mother palms already selected on a basis of a sufficient number of productive years. If this view is open to doubt, however, then it would be possible, and therefore necessary to re-examine and reconsider each year the mother palms originally selected and regularly used. This might have the advantage that considerable time could be saved in the selection of mother palms by making a provisional selection after, say, two years of observation, when artificial pollination could be started.

As the setting of the fruit, the germination and the nursery phases take about two years, one has at one's disposal yield data of two further years before planting out the material obtained and it can then be decided if this should be done or not. The drawback of such a procedure is of course that should the information obtained from the first two production years have given a false impression of the real productivie capacity of the palms concerned, then much labour and money would have been wasted on the creation of planting material which will not be used.

However, the supply of planting material on estates is not uncommonly a difficult problem and under these circumstances one may take the risk mentioned above in order to save as much time as possible.

INVESTIGATION

A scientific investigation of this problem should consist of comparison between a group of palms regularly hand-pollinated and a similar group of palms never so pollinated. Data from such palms over at least four pre-experimental productive years and a further six experimental productive years should be available and the investigation will therefore cover at least ten years.

Unfortunately we do not have these data at our disposal primarily because due to force of circumstances the A.V.R.O.S. Experiment Station had to start with artificial pollination soon after rehabilitation in 1948–49 (and particularly in 1950) on some dozens of palms selected by eye or on a basis of only one production year. It has been found possible to retain this group of palms in part, but many have had to be replaced with material selected on the

basis of data at our disposal in the succeeding years. At this stage, in order to cope with the great and urgent demand for seed, we were guided by two production years (1949 and 1950); this basis, though not entirely adequate, later appeared to be reasonably reliable.

This is one of the reasons why we have at present no palms at our disposal which revealed their high-yielding characteristics only after four years, whereupon they would have been hand-pollinated for the first time.

METHODS OF INVESTIGATION APPLIED

The A.V.R.O.S. Experiment Station has at its disposal data concerning palms frequently hand-pollinated which, though not to be treated mathematically, appear to be worth study and which could form a useful guide. For this purpose 19 Deli-dura palms, pollinated on the average three times per year per palm over 1950–1956 were compared with 21 adjacent palms, also Deli-dura, never so pollinated.

Only palms adjacent to the palms frequently pollinated are considered for control as only by this method can differences in environment be eliminated. Furthermore 5 of the 26 adjacent non-pollinated palms had to be discarded as their yields were so low that they could not be usefully compared with the frequently hand-pollinated palms.

The number of pollinations performed annually on the 19 palms were successively 65, 36, 24, 66, 40, 87 and 81 (total 399). The frequency distribution of the pollinations during the period of 7 years under consideration was as follows:

No. of pollinations	15	16	17	18	19	20	21	22	23	24	25	26	27	35	
No. of palms	1	—	4	3	2	—	—	2	2	2	1	1	—	1	19

The average bunch yield per palm during this period amounted to upwards of 1150 kg, i.e. 164·3 kg per annum. It should be noted, however, that the yield data in 1951 are obviously not reliable. The crop was not completely harvested from the trees and also the recording of the weights left much to be desired. This held good, however, for both groups of palms and it was not felt necessary therefore to exclude this year from our study.

RESULTS

For want of pre-experimental data the yields of both groups of palms could not be compared as such, as they differ fundamentally, viz. by their selection. We can, however, consider the trends of production over the years. These are set out in *Figure 1*.

From *Figure 1* it appears clearly that there exist no fundamental differences between the two groups of palms. The sharp decline in production of the 19 frequently pollinated palms in 1955 is due to the abnormally high percentage of abortive pollinations, harvested in that year, viz. 25 of the 70. Seven of these appeared to be due to monkey damage (4 on one palm) and 3 to the use of pollen which was too old. If it is assumed that these 10 abortive bunches would have had a normal average bunch weight of ca. 19 kg, then the average yield per tree would be about 10 kg more, i.e. 175 kg (1955), which would considerably offset this drop. The difference between the production graph of the 19 frequently hand-pollinated palms and the

control palms is slight. For example, should the former have yielded 10 kg less in 1952 and 10 kg more in 1954, then the similarity might have been called almost perfect, apart from the unreliable year 1951 and the year of the many unsuccessful pollinations (1955).

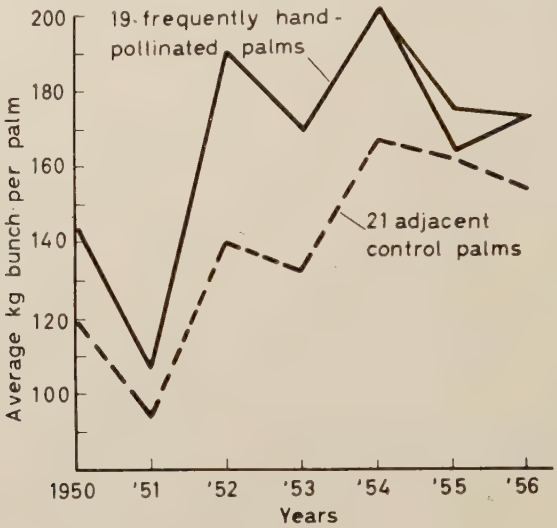

Figure 1. Production trends of 19 frequently hand-pollinated palms and 21 adjacent control palms

A certain discrepancy between the two production lines in this last year still remains, however, even if the above-mentioned monkey damage and the use of old pollen are taken into account. The possibility should therefore be investigated whether this divergence may perhaps be caused by the accumulated influence of the artificial pollinations already performed over many years. Considering, however, the 19 much-pollinated palms individually, it appears that the palms which are responsible in particular for the relatively sharp production fall in 1955 are both those very frequently pollinated and those less frequently pollinated, whilst among the 5 or 6 palms which showed no decline in 1955 or even a rise were some of the most frequently pollinated ones. Nor can it be said that the palms which were the particular cause of the very sharp rise in 1952 were more or less frequently pollinated in the preceding years (1950 and 1951) than those which contributed least to this rise.

CONCLUSION

The similarity between the production trend lines of a number of palms artificially pollinated relatively frequently between 1950–56 (an average of three times per year per palm) and a number of comparable palms never so pollinated suggests that artificial pollination has neither a favourable nor unfavourable effect on the subsequent yield. The relatively small divergences between the trends cannot be ascribed to the influence of artificial pollination.

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The Application of Foliar Analysis to Oil Palm Cultivation—IV. The Diagnosis of Multiple Deficiencies

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In previous papers (Broeshart, 1955, 1956) it has been shown that the diagnosis of single deficiencies by means of leaf analysis is possible. To ascertain the nutritional status of plantations, however, many samples have to be analysed and only a comparatively small part of the variation in leaf composition may be explained or interpreted. Because of the variation in soil fertility, the chemical composition of some of the leaf samples in areas suffering from two or more deficiencies will indicate a single deficiency, but in the majority of the samples the chemical composition will be the result of the combined effect of all deficiencies.

To widen the scope of the foliar analysis technique with regard to the diagnosis of potassium, phosphorus and magnesium deficiencies, which are most frequently encountered in the Belgian Congo, an experiment was carried out whereby the effect of multiple deficiencies on leaf composition was determined. Deficiency symptoms were also studied in relation to varying nutritional conditions.

DESCRIPTION OF THE EXPERIMENT

Germinated seeds were planted in half 500-litre drums filled with river-washed sand (Broeshart, Ferwerda and Kovachich, 1957). Each drum contained about 180 seedlings and received a complete nutrient solution during six months. Thereafter a 3^4 factorial experiment was begun, comprising three levels (0, 1 and 2) of potassium, magnesium, phosphorus and sulphur with confounding of some of the higher order interactions. Although sulphur deficiency in oil palm has not yet been encountered in the Belgian Congo, it might be induced, if, for instance, potassium is given as chloride, and phosphorus as rock phosphate. Sulphur was therefore included in the treatment.

Each drum received 2 litres of solution daily; this quantity was increased to 4 litres after 5 months' treatment. The nutrient solution, based on one recommended by Hewitt (1952) but slightly modified for the purpose of the experiment, was of the following composition (2222 levels):

K^+	3·33 mequiv./l.		Fe^{3+}	0·33 mequiv./l.
Mg^{2+}	6	,,	Mn^{2+}	0·02 ,,
Ca^{2+}	6·67	,,	Cu^{2+}	0·002 ,,
Na^+	7	,,	Zn^{2+}	0·002 ,,
$(NO_3)^-$	10	,,	B	0·033 millimole/l.
$(PO_4)^{3-}$	4	,,	Mo	0·0002 ,,
$(SO_4)^{2-}$	3	,,		
Cl^-	6	,,		

For the single levels, half of the quantities of potassium, phosphorus, magnesium and sulphur was given. Cations, if omitted, were replaced by Na^+ and anions by Cl^-. The pH of each solution was adjusted to 5·6 by means of sodium hydroxide or hydrochloric acid. A part of the seedlings was removed at monthly intervals and an analysis of the youngest leaves was made, comprising determinations of the potassium, magnesium, calcium, phosphorus and ash contents. After 5 months' treatment, one single palm was retained in each drum. Subsequent samples consisted of leaflets from the centre part of the youngest fully open leaf.

GROWTH AND DEFICIENCY SYSTEMS

Growth measurements, including height, total number of leaves, number of green and number of desiccated leaves, were taken after 12 months' treatment. Magnesium, phosphorus and sulphur deficiency caused reductions of height, number of leaves and number of green leaves, but an increase of the number of chlorosed or dry leaves. When potassium was deficient, only a reduction in height was observed. After six and twelve months the incidence of deficiency symptoms was recorded. The symptoms observed comprised:

(*1*) Orange colour spreading over older leaves (BULL, 1954);
(*2*) White spots on younger leaves (BROESHART, 1956);
(*3*) Pale green over all leaves;
(*4*) Necrotic spots on all leaves;
(*5*) Reduced growth of younger leaves;
(*6*) Marginal scorch and complete necrosis of older leaves;
(*7*) Erect habit of entire palm;
(*8*) White chlorotic streaking described as infectious chlorosis (WARDLAW, 1951).

Table 1. Incidence of deficiency symptoms after six and twelve months' treatment, expressed in numbers of palms affected

Main effects	*Orange*		*White spots*		*Pale green*		*Necr. spot*		*Reduced growth*	*Marg. scorch*	*Erect habit*	*White Chlorotic streaking*
	6 mos	*12 mos*	*6 mos*	*12 mos*	*6 mos*	*12 mos*	*6 mos*	*12 mos*	*6 mos*	*12 mos*	*12 mos*	
K_0	8	7	4	4	5	6	3	7	13	7	18	7
K_1	9	9	0	0	9	9	6	9	1	15	9	1
K_2	9	9	0	0	7	8	4	8	3	8	18	0
Mg_0	26	25	1	0	5	6	1	6	9	0	12	3
Mg_1	0	0	1	2	9	9	6	10	4	16	13	4
Mg_2	0	1	2	2	7	8	6	8	4	16	14	1
P_0	8	7	3	1	6	8	3	8	4	12	17	1
P_1	9	9	1	2	8	8	7	8	7	10	11	3
P_2	9	10	0	1	7	7	3	8	6	8	11	4
S_0	8	9	0	0	20	22	12	22	3	9	17	1
S_1	9	9	0	0	0	1	0	1	8	11	12	3
S_2	9	9	3	3	1	0	0	0	5	10	10	4

Table 1 gives the main effects of the incidence of each symptom. It may be seen that the orange colour corresponds with magnesium deficiency and is not influenced by the presence of other deficiencies. White spots on the younger leaves occur when potassium is deficient; when magnesium or sulphur are simultaneously deficient with the potassium deficiency, the white spots appear less frequently. Pale green is associated with sulphur

deficiency and does not seem to be influenced by any other deficiency. The green colour does not differ from that associated with nitrogen deficiency. Necrotic spotting is also associated with sulphur deficiency, but is less severe in the first stage particularly when magnesium is simultaneously deficient.

Table 2. Chemical composition of youngest fully open leaf, expressed as dry matter

Main effects	% K	% Ca	% Mg	% P	% N	% Ash
K_0	0·91	0·738	0·248	0·238	3·32	7·16
K_1	1·91	0·612	0·224	0·229	3·25	7·94
K_2	2·06	0·586	0·219	0·226	3·23	8·07
Mg_0	1·68	0·779	0·163	0·234	3·24	8·20
Mg_1	1·61	0·610	0·258	0·230	3·29	7·60
Mg_2	1·60	0·547	0·269	0·228	3·27	7·38
P_0	1·63	0·644	0·226	0·203	3·24	7·45
P_1	1·60	0·641	0·237	0·239	3·28	7·85
P_2	1·66	0·651	0·228	0·250	3·27	7·88
S_0	1·62	0·653	0·238	0·235	3·31	7·74
S_1	1·61	0·656	0·224	0·229	3·22	7·80
S_2	1·64	0·626	0·229	0·227	3·26	7·63
Sign. main effect at P=0·05	0·16	0·066	0·016	0·025	0·20	0·44
Sign. main effect at P=0·01	0·20	0·083	0·020	0·031	0·26	0·55

The reduction in growth is very marked when potassium is deficient, marginal scorch and necrosis of the oldest leaves being intense in conjunction with the higher levels of magnesium. Both marginal scorch and necrosis of the oldest leaves were completely absent in the orange leaves of the magnesium-deficient palms. The erect habit is found most frequently when potassium, phosphorus or sulphur are deficient. Infectious chlorosis is associated with potassium deficiency; the incidence is higher when neither phosphorus nor sulphur are deficient.

ANALYTICAL RESULTS

Figure 1 gives the average leaf compositions in the experiment at monthly intervals, together with the most important treatment effects. The monthly variation may partly be explained on account of the changes in climatological conditions, which are similar to the changes observed in the leaves of plantation palms with regard to the phosphorus and magnesium contents (Broeshart, 1955, 1956). The phosphorus content is high during the dry season (Dec. to Feb.) and magnesium is high during the small dry season in June and July.

The nitrogen, ash and calcium contents were low during the beginning of the rainy season in March, April and May.

It may be observed from *Figure 1* that the graphs for the means and the main effects are almost parallel, suggesting that interactions between time of sampling and treatments are small and insignificant. For the calculation of the factorial effects, the averages over the year were used and the estimation of the error variance was made by pooling the errors of 9 months.

The main effects have been given in *Table 2*. The changes in composition with potassium, magnesium and phosphorus deficiency confirm previous findings from the results of fertilizer and sand culture experiments. Potassium deficiency decreases the potassium and ash contents but increases calcium and magnesium. The phosphorus content increased slightly. Magnesium deficiency decreases the magnesium content, but increases the calcium and ash contents. Phosphate deficiency decreases phosphorus and ash contents.

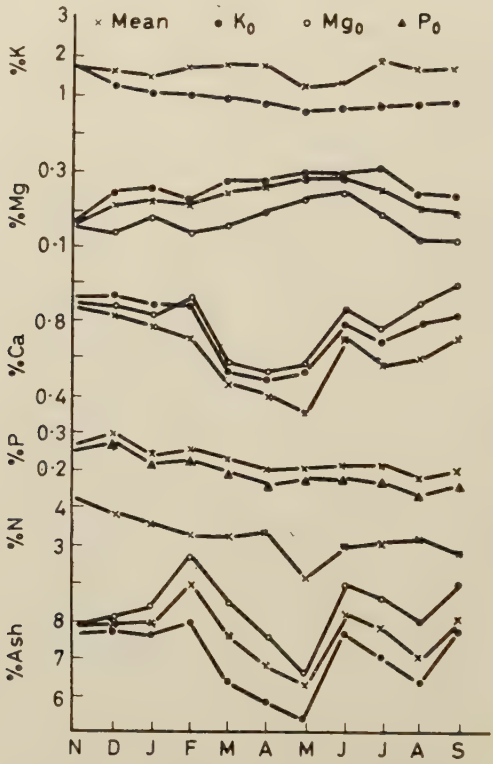

Figure 1. Monthly variation in leaf composition

Sulphur deficiency had no influence on the concentration of any of the elements considered in this work.

The interactions for the single and double levels of potassium, magnesium, phosphorus and sulphur with the exception of the Mg × K interaction on the magnesium content are small and not significant at $P=0{\cdot}05$.

The actual changes in leaf composition for each two-factor combination of potassium, magnesium and phosphorus may be seen from *Table 3*.

The potassium content of leaves is low when potassium is deficient. Magnesium deficiency increases the potassium content when potassium is not deficient.

The magnesium content is low when magnesium is deficient. Potassium deficiency increases the magnesium content if magnesium is not deficient.

The phosphorus content is low when phosphorus is deficient. When phosphorus is not deficient, magnesium and potassium deficiency tend to increase the phosphorus content.

Table 3. Effect of two-factor combinations on leaf composition

		% K	% Ca	% Mg	% P	% N	% Ash
Mg_0	K_0	0·91	0·920	0·166	0·239	3·33	7·54
Mg_0	K_1	1·98	0·719	0·162	0·233	3·20	8·41
Mg_0	K_2	2·13	0·696	0·162	0·230	3·20	8·64
Mg_1	K_0	0·87	0·696	0·286	0·241	3·31	7·06
Mg_1	K_1	1·93	0·579	0·247	0·228	3·28	7·93
Mg_1	K_2	2·04	0·555	0·242	0·221	3·26	7·82
Mg_2	K_0	0·96	0·598	0·295	0·234	3·30	6·89
Mg_2	K_1	1·84	0·536	0·261	0·225	3·26	7·49
Mg_2	K_2	1·99	0·505	0·252	0·225	3·23	7·75
P_0	K_0	0·93	0·749	0·245	0·207	3·29	6·96
P_0	K_1	1·87	0·602	0·214	0·201	3·25	7·50
P_0	K_2	2·09	0·579	0·218	0·201	3·19	7·89
P_1	K_0	0·88	0·740	0·248	0·245	3·32	7·28
P_1	K_1	1·92	0·617	0·237	0·240	3·24	8·13
P_1	K_2	1·99	0·576	0·226	0·232	3·28	8·13
P_2	K_0	0·92	0·736	0·254	0·261	3·34	7·26
P_2	K_1	1·96	0·616	0·220	0·246	3·25	8·19
P_2	K_2	2·09	0·601	0·212	0·244	3·22	8·19
P_0	Mg_0	1·69	0·752	0·162	0·203	3·22	7·86
P_0	Mg_1	1·58	0·621	0·249	0·204	3·28	7·38
P_0	Mg_2	1·63	0·558	0·267	0·202	3·24	7·11
P_1	Mg_0	1·59	0·778	0·171	0·237	3·22	8·19
P_1	Mg_1	1·63	0·603	0·268	0·238	3·32	7·72
P_1	Mg_2	1·57	0·542	0·272	0·241	3·30	7·62
P_2	Mg_0	1·75	0·806	0·157	0·260	3·29	8·53
P_2	Mg_1	1·62	0·607	0·259	0·249	3·26	7·71
P_2	Mg_2	1·60	0·540	0·269	0·242	3·26	7·40
Sign. Diff. $P=0·05$		0·28	0·116	0·028	0·042	0·35	0·76
Sign. Diff. $P=0·01$		0·35	0·145	0·035	0·054	0·45	0·96

As soon as potassium, magnesium or phosphorus reach deficient levels their concentration is very little influenced by other deficiencies. The antagonistic action between two elements is limited to the increasing effect of the deficient elements on the non-deficient one. The calcium content increases when potassium or magnesium are deficient. When both potassium and magnesium are deficient, the calcium content becomes very high; the interaction is positive. The ash content decreases when potassium and phosphorus are deficient, but increases when magnesium is deficient. It may be seen that the decrease in ash content, when potassium is deficient, is counterbalanced by the increase in ash content if magnesium is simultaneously deficient. The decrease in ash content when both phosphorus

and potassium are deficient is greater than for a single potassium or phosphorus deficiency. This suggests that the change in the ash content in a multiple deficiency is the result of the additive effect of both deficiencies. The nitrogen content is very little influenced by any of the deficiencies.

DISCUSSION

Some remarks may be made concerning the value of deficiency symptoms for the diagnosis of multiple deficiencies. Magnesium deficiency symptoms, i.e. the orange colour of the older leaves, appear very quickly and tend to mask other deficiency symptoms such as the white spotting of potassium deficiency and the necrotic spotting of sulphur deficiency. The same may be said of sulphur deficiency, which reduces the incidence of the white spotting when potassium is simultaneously deficient. If the white chlorotic streaking known as infectious chlorosis is considered as a potassium deficiency symptom, its incidence is less when phosphorus or sulphur are deficient as well. Marginal scorch, which is often associated with potassium deficiency, is not critical for this deficiency, as it may occur with other deficiencies as well. Marginal scorch was absent in the Mg_0 treatments. The design of the experiment did not permit, however, the elucidation of whether magnesium deficiency prevented the appearance of marginal scorch, or whether the marginal scorch in the Mg_1 and Mg_2 treatments was caused by another factor. In this respect chlorine toxicity may be mentioned, as magnesium in the experiment was given as magnesium chloride. The erect habit was associated with all deficiencies, and is not, therefore, of specific diagnostic value. These examples illustrate the limited value of deficiency symptoms as indicators of multiple deficiencies.

In the Belgian Congo, simultaneous deficiency of magnesium and potassium occurs very frequently, so that the diagnosis of potassium deficiency by means of visual symptoms only is difficult. The statement does not imply that the use of deficiency symptoms for diagnosis is of little value; on the contrary, as a preliminary indication it is of considerable value for those concerned with the fertilizing of oil palm areas. It is advisable, however, that conclusions based on the results of a symptom survey be checked by subsequent foliar analysis.

With regard to the white chlorotic streaking of leaves which only occurred in the K_0 treatments, it is possible that we are dealing with a true potassium deficiency symptom. In this matter the findings of HEWITT and BULL may be mentioned: they found a high incidence of chlorotic streaking in the K_0 plots of a fertiliser experiment in Nigeria (1956).

Confluent orange spotting was observed in one case only for the $K_1Mg_0P_1S_2$ treatment. BULL's (1954) statement that this symptom is characteristic for potassium deficiency may be doubted on account of the results of this experiment. The possibility still exists, however, that confluent orange spotting is characteristic of a disease or other abnormal condition which is associated with potassium deficiency under local conditions (COULTER and ROSENQUIST, 1955).

The diagnosis of multiple deficiencies by means of foliar analysis is facilitated by the fact that the level of a deficient element in the leaf is very little influenced by other deficiencies. Antagonisms generally occur between

elements of which only one is deficient. It was shown, however, that the interactions were often small and that the effect of two deficiencies on the composition of leaves may be represented by the effect of the single deficiencies added together.

The levels of the elements in the leaves of this experiment were obtained by averaging the results for each treatment over a 9-month period. A considerable influence of the monthly variation in leaf composition has thus been included, which affects the absolute level of the mean. Therefore, the absolute values should not be taken for comparison with the levels of elements in plantation palms, which are usually sampled during a well defined period of the year. The trends shown by the averages may be used for extrapolation, because it was shown that the interactions between sampling time and treatments were very small.

The changes in leaf composition due to single and multiple deficiencies of potassium, magnesium and phosphorus may be represented by positive and negative deviations from the 'Normal leaf composition' (BROESHART, 1954, 1955, 1956) in the following ways:

Deficiency	% K	% Mg	% Ca	% P	% N	% Ash
K	–	+	+	(+)	0	–
Mg	(+)	–	+	0	0	+
P	0	(–)	(–)	–	0	–
K+Mg	–	–	+	0	0	0
K+P	–	+	+	–	0	–
Mg+P	0	–	+	–	0	0

— lower than normal
0 normal
( ) small change
+ higher than normal

Sulphur deficiency had no influence on any of the elements analysed. There is a risk that sulphur deficiency may be induced when magnesium and potassium have been given as chlorides and phosphorus as rock phosphate. In that event, analysis of the potassium, magnesium, calcium, phosphorus and ash contents will not show any nutritional disorder. It will thus be necessary to include other elements in the analysis, presumably the sulphur content. This fact immediately draws attention to the limited value of foliar analysis as a diagnostic method, unless all the elements of nutritional value, including trace elements, are determined. With regard to sulphur deficiency, the symptoms fortunately are very characteristic and appear rather quickly.

If sulphur deficiency symptoms be mistaken for nitrogen deficiency, the nitrogen content, which is normal when sulphur is deficient, but very low when nitrogen is lacking, may be used as a check on the diagnosis. In that respect the oil palm compares favourably with rubber, where the nitrogen contents of nitrogen-deficient and sulphur-deficient trees are very similar (BOLLE-JONES, 1956).

SUMMARY

The effects of multiple deficiencies on the chemical composition of the leaves and on the incidence of symptoms in young oil palms have been investigated in a sand culture experiment. It has been shown that a reliable diagnosis of nutritional disorders in the oil palm cannot be based

on visual symptoms only, but should be checked by subsequent foliar analysis. Symptoms, characteristic for a particular deficiency, may be masked by the symptoms of a second deficiency.

The level of a deficient element in the leaf is very little influenced by other deficiences and antagonisms generally occur between elements of which only one is deficient.

Characteristic changes in leaf composition are given for the combination of K + Mg, K + P, and P + Mg deficiency, which are frequently encountered in the Belgian Congo.

Sulphur deficiency may be induced, if the fertilizer applications do not include sulphur. Sulphur deficiency symptoms, consisting of a pale green necrotic spotting, appear quickly. The levels of potassium, calcium, magnesium, phosphorus, nitrogen and ash then remain normal.

The white chlorotic streaking known as ' Infectious chlorosis ' would seem to be either a true potassium deficiency symptom, or an abnormal condition associated with potassium deficiency.

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REFERENCES

Bolle-Jones, E. W. (1956). ' Molybdenum status of laminae as dètermined by bioassay and chemical methods.' *Plant & Soil* **7,** 130

Broeshart, H. (1954). ' The use of foliar analysis in oil palm cultivation.' *Trop Agriculture, Trin.* **31,** 251

— (1955a). ' The use of foliar analysis in oil palm culture.' *Trans. 5th int. Congr. Soil Science, Leopoldville* Vol. III

— (1955b). ' The application of foliar analysis in oil palm cultivation.' *Thesis, Wageningen*

— (1956). ' The application of foliar analysis to oil palm cultivation I, II, III.' *Trop. Agriculture, Trin.* **33,** 127, 238, 315

— Ferwerda, J. D. and Kovachich, W. G. (1956). ' Mineral deficiency symptoms in the oil palm.' *Plant & Soil,* 1957 (in press)

Bull, R. A. (1954). ' Studies on the deficiency diseases of the oil palm.' *J. W.Afr. Inst. Oil Palm Res.* No. **2,** 94

Coulter, J. K. and Rosenquist, E. A. (1955). ' Mineral nutrition of the oil palm.' *Malay. Agric. J.* **38,** 214

Hewitt, E. J. (1952). ' Sand and water culture methods used in the study of plant nutrition.' *Tech. Comm.* 22, Commonwealth Bureau of Horticulture and Plantation Crops

— and Bull, R. A. (1956). ' A preliminary survey of deficiency symptoms in crop plants in the oil palm belt of Nigeria.' *J. W.Afr. Inst. Oil Palm Res.* No. **4,** 53

Wardlaw, C. W. (1951). ' Notes on a seedling disease of the oil palm tentatively diagnosed as a virus disease: infectious chlorosis.' Illustrated *Report* to the United Africa Co., London. Limited Circulation.

Banana Cultivars in East Africa

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Late in 1948 Baker and Simmonds (1951, 1952) made a survey of the banana cultivars of Kenya, Uganda, Tanganyika and Zanzibar, an area with an ancient tradition of banana cultivation. A number of the clones seen were recognizable as identical with clones grown in the West Indies and other parts of the tropics. Many of these were, however, clearly regarded by the Africans as recently introduced ' alien ' sorts. The majority of cultivars were unfamiliar and were evidently distinct from those known from other banana-growing areas. Comparisons in the field were made difficult by the infrequent occurrence of some sorts, by environmental variability induced by varying soils and climates, and by the occurrence of somatic mutations. Native names were not of much help in solving these difficulties because they were often of very limited distribution and, even in a small area, often far exceeded in number the number of clones actually present.

The clones ' Kinguruwe ', ' Ichokosi ' (=' Mkojosi '), ' Nyeupe ya Kizungu ' and ' Sukari ' of the Amani, Tanganyika, collection were established in Trinidad in 1938–39 and have since been identified with other well known sorts. Subsequent to the 1948 survey 47 other clones were established here. A few of them did not match the notes of Baker and Simmonds and their names have been rejected from consideration; the possibility of other similar errors cannot be entirely discounted and further doubts will be mentioned in their context. The remaining introductions have almost all been compared in some detail with our standard collection of clones and with each other. Hence, with the assistance of the field notes, a critical account can now be given of a considerable number of the East African cultivars. Some suggested synonymies or affinities are based solely on the field notes and should therefore be regarded as provisional. In some instances, photographs have aided identification, although their diagnostic usefulness is limited.

CLASSIFICATION

Bananas originated in southeast Asia. Cultivated (i.e. edible, parthenocarpic) forms are sometimes diploid ($2n=22$) but commonly triploid, while one known cultivar (not recorded in East Africa) is tetraploid. Cheesman (1948) assigned their origins to two wild species, *Musa acuminata* Colla and *M. balbisiana* Colla. Simmonds and Shepherd (1955) demonstrated that cultivars of Malaysian origin were generally diploid or triploid clones of *M. acuminata*; the Indian bananas, by contrast, were mainly triploids of interspecific hybrid origin. With the exception of one known diploid F_1 sort and the above-mentioned tetraploid, hybrid clones matched the expected phenotypes for one or other of the two possible allotriploids; the

constitution of a clone can then be stated briefly by means of a formula, as AA, AAA, AB, AAB or ABB, where 'A' represents a haploid chromosome set (genome) of *M. acuminata* and 'B' a set from *M. balbisiana.*

Ultimate diagnosis is based on the dimensions and coloration of the pseudostems and leaves, on the angle and pubescence of the peduncle, on the form, size and ripe characters of the bunch and fruits, on the coloration of the rachis, and on the form, colour and persistence of the male bud, bracts and flowers.

The spelling of clonal names follows that of Baker and Simmonds (1952). Type numbers are those of the I.C.T.A. standard collection of clones. A Type name is chosen arbitrarily and is usually that of the first accession found to be distinct in each case.

CULTIVARS OF WIDE DISTRIBUTION IN THE TROPICS

A list of probable identities was given by Baker and Simmonds (1951). This has been expanded and slightly modified in *Tables 1* to *3* and now comprises seven *acuminata* types (AA and AAA) and eight hybrid types (AB, AAB and ABB). Asian names have been recorded from accessions into our collection, or are from SIMMONDS (unpublished) or from JACOB (1952).

CLONES KNOWN ONLY FROM EAST AFRICA

AA group—diploid acuminata types

Such types are rare except in Zanzibar. Those introduced to Trinidad are as follows:

'Small type' (Kawanda)—allegedly an alien; a short inferior type with small horizontal bunches; susceptible to Panama Disease and Leaf Spot. I.C.T.A. Type 41.

'Mchare'='Nshonowa' (Moshi)—rather tall and slender with an oblique bunch of fair size; slightly seedy; male bud dark red; susceptible to Panama Disease and Leaf Spot. Type 56.

'Zahala'='Nkokoma' (Amani)—a freak plant with few hands and few fruits; susceptible to Panama Disease and Leaf Spot. Type 50.

'Paka' (Zanzibar)—tall, pale, with large pendulous bunches, greenish when ripe; rachis naked; male bud yellow; Panama Disease occasional and Leaf Spot slight. Type 39.

'Mhalihali' (Zanzibar)='Lua lua' (Amani)—tall, blackish, with large oblique to pendulous bunches, fruits long on longish stalks; many neuter flowers, male bracts and flowers persistent; male bud yellow; susceptible to Leaf Spot. Type 54.

'Sikuzani' (Zanzibar)—tall, pale with large oblique to pendulous bunches; rachis naked; male bud pale reddish-brown; susceptible to Leaf Spot. Type 38.

'Pukute' (Zanzibar)—similar to last but shorter, darker and with smaller, oblique to horizontal bunches and smaller fruits; susceptible to Leaf Spot. Type 51.

'Mjenga maua' (Zanzibar)='Mlali maua' (Pemba)—medium-tall, moderately marked with black; bunch oblique, of 4 to 6 hands; bracts and male flowers persistent; male bud dull red-purple; anthers abortive; susceptible to Panama Disease and Leaf Spot. Type 40.

Table 1. Cultivars with known extra-African distribution: acuminata *(AA and AAA) types*

Clone (notes)	*I.C.T.A. Type*	*Constitution*	*Kenya*	*Uganda*	*Tanganyika*	*Zanzibar*	*Asia*
'Sucrier'	19	*AA*	—	—	*'Kisukari cha kamba' (Amani)*	*'China'*	*'Pisang mas' (Malaya)*
'Bande' (1)	22	*AA*	*? *'Gatumia' (Kiambu)*	—	—	*'Mjenga' *'Mlali kifupa' (Pemba)*	—
'Gros Michel'	1	*AAA*	—	? *'Malaya' (Kawanda)* *'Sweet Jamaica' (Kawanda)*	? *Present, unnamed (Bukoba)*	—	*'Pisang ambon' (Malaya)*
'Dwarf Chinese' (2)	2	*AAA*	*'Nyoro' (Kiambu)* *Unnamed (Kisumu)*	*Unnamed (Kawanda)*	**'Kinguruwe' (Moshi)*	*'Kinguruwe'*	*'Pisang serendah' (Malaya)*
'Congo' (2)	4	*AAA*	—	—	—	*'Mtwike'*	*'Pisang berangan' (Malaya)*
'Red'	7	*AAA*	*'Nyeuse' (Kiambu)* *Unnamed (Kisumu)*	*'Red banana' (Kawanda)*	*Unnamed (Bukoba)* *'Kikanda' (Moshi)* *'Mgomba wa Uganda' (Moshi)* *'Ndizi Uganda' (Moshi)* *'Nyekundu ya Kizungu' (Amani)* *'Bokoboko' (Amani)*	*'Mzungu mwekundu'* *'Bungala' (Pemba)*	*'Pisang raja udang' (Malaya)*
'Green red'	7A	*AAA*	—	—	*'Kikanda' etc. (Moshi)* **'Nyeupe ya Kizungu' (Amani)* *'Bokoboko' (Amani)*	*'Mzungu mweupe'* *'Buki' (Pemba)*	*'Pisang mundam' (Malaya)*

NOTES: (1) 'Gatumia' as received in Trinidad is identical with 'Bande' but does not agree closely with the field notes. Confusion is possible. Of the mainland clones listed, only 'Gatumia' is alleged to be 'native'.

(2) 'Dwarf Chinese' and 'Congo' are related by somatic mutation as are also 'Red' and 'Green red'. For a general synonymy in the Cavendish group see SIMMONDS (1954b).

* Clones grown and compared in Trinidad.

Table 2. Cultivars with known extra-African distribution: hybrid (AB and AAB) types

Clones (notes)	*I.C.T.A. Type*	*Constitution*	*Kenya*	*Uganda*	*Tanganyika*	*Zanzibar*	*Asia*
'Ney poovan'	20	*AB*	*'Guindi' (Kiambu)* ? *'Wangae' (Kiambu)* *'Sukari' (Kisumu)*	*'Sukari' (Ankole)*	*'Kisukari' (Moshi)* *'Ngusu' (Moshi)* *'Kipukusa cha Java' (Amani)*	—	*'Ney poovan' (Madras)*
'Mysore'	6	*AAB*	—	—	*Unnamed (Moshi)*	*'Kikonde'*	*'Poovan' (Madras)*
'Pome'	15	*AAB*	—	—	*'Kibungala' (Amani)*	**'Kijakazi'*	**'Virupakshi', etc. (Madras)*
'Silk'	17	*AAB*	—	—	*'Kipungusa' (Moshi)* *'Sukari' (Amani)*	*'Kipukusa'*	**'Rastali' (Madras)* *'Safet elchi' (Bombay)* *cf. 'Moongil' (Madras)*
'Horn plantain' (1)	23	*AAB*	—	*'Gonja mamba' (Fort Portal)*	**'Nkonjwa chayaya' (Bukoba)* *'Mbo', 'Mbwe', 'Msusu' (Moshi)* *'Mkono wa tembo' (Moshi, Amani)*	*'Mkono wa tembo'* *'Msinyore'*	*'Pisang tandok' (Malaya, etc.)*
'French plantain' (1)	24	*AAB*	*? *'Nyakahe' (Kiambu)*	*'Gonja' (Kawanda)* *'Manjaya' (Masaka)*	**'Nkonjwa' (Bukoba)* **'Nshakara' (Bukoba)* *'Kipanje' (Amani)* *'Muhoye' (Amani)*	**'Mporo moka'* **'Kichaange'* **'Mchinja damu'* *'Mzuzu'*	*'Nendran' (Madras)* *'Eleri' (Madras)*

NOTES: (1) Somatic mutations are prevalent in the 'Plantain' group, some members of which are evidently 'native' clones long cultivated in East Africa. The group falls naturally into two classes: the 'Horn plantains', with few hands of large fruits and no male buds; and the 'French plantains' with more numerous hands of smaller fruits, long-lived male buds and persistent bracts. 'Nkonjwa chayaya' and 'Mkono wa tembo' are our type form of the first. 'Msusu', 'Mbo', 'Mbwe' and 'Msinyore' are said to have more hands and fruits. 'Gonja mamba' is of uncertain status. One of our introductions, apparently erroneously labelled 'Nkonjwanshansha', is redder and normally has but one hand of immense fruits and no male rachis at all. This is surely 'Moongil' of Madras from Jacob's picture and description. The pale 'French plantain' type is represented by 'Nkonjwa' and 'Mporo moka', though the latter may be shorter. 'Nshakara' has a pinker pseudostem. 'Mchinja damu' has a very red stem (cf. 'Wine plantain' of the West Indies). 'Kichaange' has the type coloration but the fruits have rounded, non-tapering tips. A clone received as 'Nyakahe', but not agreeing with the field notes, is similar to the type but seems to have a smaller and rather oblique bunch. The other listed clones cannot yet be assessed.

* Clones grown and compared in Trinidad.

Table 3. Cultivars with known extra-African distribution: hybrid (ABB) types

Clones (notes)	*I.C.T.A. Type*	*Constitution*	*Kenya*	*Uganda*	*Tanganyika*	*Zanzibar*	*Asia*
'Bluggoe' (1)	11	*ABB*	—	? *'Kijozi'* (*Kawanda*) ? *'Kivuvu'* (*Kawanda*)	**'Mkojosi'* (*Moshi*) *'Ikonosi'* (*Moshi*) *'Bokoboko'* (*Amani*)	*'Koroboi'* *'Muskat'* *'Punda'* (*Pemba*) *'Bokoboko'* (*Pemba*)	*'Nalla bontha'*, *etc.* (*Madras*)
'Awak legor' (2)	12	*ABB*	**'Nyeupe'* (*Kiambu*) ? *'Munjuu'* (*Kiambu*) ? *'Muchero'* (*Kiambu*) ? *'Ngongia'* (*Kisumu*)	— —	— —	— —	*'Pey kunnan'* (*Madras*) **'Pisang awak (legor)'* (*Malaya*)

NOTES: (1) Subclones of 'Bluggoe' exist with fruits more or less waxy rather than dull green, and this distinction is made in Zanzibar and Pemba within the collective names 'Koroboi', 'Muskat' and 'Punda'. Some subclones, in the same islands, are reputed to have blunt-tipped instead of bottlenecked fruits. Members of this 'Bluggoe' group are evidently 'native' types long established in coastal areas.

(2) 'Pisang awak' and 'Pisang awak legor' are commonly separated in Malaya on the grounds that the latter is more seedy (SIMMONDS, unpublished). 'Nyeupe' may in fact be less seedy than I.C.T.A. material of 'P. awak legor' but is otherwise indistinguishable from it. 'Munjuu' and 'Muchero' probably belong here; they are accepted 'native' clones.

* Clones grown and compared in Trinidad.

Comments on disease susceptibility are from field observations made in Trinidad; resistance to Panama Disease cannot be definitely assumed for any type. ' Paka ', ' Mhalihali ' and ' Sikuzani ' have potential value for banana breeding, their bunches being uncommonly large by diploid standards.

AAA group—triploid acuminata types

A large proportion of such clones established in Trinidad can be dealt with collectively. Apart from evident cases of synonymy, these clones have many common attributes. Stems are usually green with rather heavy black marking and with purplish undersheaths. Male buds are identically dull brownish-purple with paler streaks; the inner face of the bract is creamy, variably flushed with rather streaky pink. Male flowers are uniformly pale with yellow teeth and orange-yellow style and stigma. The fruit bunch ripens unevenly and with a remnant greenish tinge especially near the fruit apices. The flesh is sticky and ochreous yellow, the flavour thin, somewhat astringent but sweet and acceptable.

Table 4. A probable complex of AAA type somatic mutants

1. ' Mutika ' group	*2. ' Lujugira ' group*
(*a*) *' *Mutika* ' (*Kiambu*) *Type 43* *' *Mitahato* ' (*Kiambu*) *' *Nchoncho* ' (*Bukoba*)	(*a*) *' *Lujugira* ' (*Kawanda*) *Type 44* *' *Muthirire* ' (*Kiambu*) *' *Lyswa* ' (*Kisumu*) ' *Irithwa* ' (*Kisumu*) *? ' *Nakabinyi* ' (*Kawanda*) ' *Nakamali* ' (*Kawanda*) *' *Ndishi* ' (*Moshi*) ' *Ifwanaiya* ' (*Moshi*) ' *Nduuya* ' (*Moshi*)
(*b*) *' *Nandigobe* ' (*Kawanda*) ' *Lwondo* ' (*Kawanda*) ' *Enjagara* ' (*Toro*) ' *Njagate* ' (*Ankole*) ? ' *Nshansha* ' (*Bukoba*)	
(*c*) *' *Gitigi* ' (*Kiambu*) *Type 42* ' *Gatika* ' (*Kiambu*) *' *Nduyu* '(*Kiambu*)	(*b*) *' *Lwekilo* ' (*Bukoba*) *Type 47* *' *Mboko* ' (*Amani*)
	(*c*) *' *Nakabululu* ' (*Kawanda*) *Type 53* ? ' *Ndizabaulu* ' (*Kawanda*) ' *Bukumo* ' (*Ankole*) ' *Nkunku* ' (*Ankole*) ' *Namangulungu* ' (*Ankole*)
	(*d*) ' *Nakabululu omudugavu* ' (*Kawanda*)
	(*e*) *' *Ntobe* ' (*Bukoba*) *Type 48*

* Clones grown and compared in Trinidad.

It is suggested that the diversity of types conforming to this general description has arisen by somatic mutation. Some differences are apparent on casual inspection, others may require randomized plantings and the accumulation of plant measurements (as SIMMONDS (1954a) found with the ' Cavendish ' group). Where mutants for plant height are concerned, leaf ratio seems to be the character least affected by environment and therefore to be of most use for diagnosis. The leaf ratio is the quotient of lamina length over maximum width taken from the third or fourth leaf below the bunch. The types already recognized, with their certain or possible synonyms, are shown in *Table 4.*

The first column (1. ' Mutika ' group) includes clones with more or less pendulous, heavy bunches and medium to longish fat fruits, conspicuously bottlenecked even at maturity. ' Mutika ' (1a), if our material is authentic, represents the tall form with a leaf-ratio of 2·7 to 3·3. ' Nandigobe '(1b) is distinguished by its tendency to persistence of the male flowers and bracts, ' Gitigi ' (1c) is about 50 cm shorter, with a leaf-ratio of 2·1 to 2·4 and also tends to bract persistence. The tall clones may require further subdivision. Another introduction, clearly misnamed, was identical with ' Mutika ', except that it has a strong pink flush on the petioles.

Clones in the second column (2. ' Lujugira ' group) have shorter, less bottlenecked fruits; all are tall. ' Lujugira ' (2a) has a heavy, more or less vertical bunch. ' Nakabinyi ', according to the field notes, had a horizontal male axis, but this character has not been observed in the imported material which must therefore be considered doubtful as to identity. ' Lwekilo ' (2b) differs only in the intense purple-black coloration of the pseudostem and petioles; one of the plants of this clone established in Trinidad produced a ratoon tree indistinguishable from ' Lujugira '. ' Nakabululu ' (2c) has oblique bunches with shorter intervals between the hands and between the bracts of the male rachis; the male axes are thus shorter and the male buds characteristically short and fat. ' Nakabululu omudugavu ' (2d) is said to be a black-stemmed variant. ' Ntobe ' (2e) is yet more compact, with small, nearly horizontal bunches and rounded male buds; also, the bracts and male flowers are somewhat persistent in this type.

Other distinct triploid sorts recognized are:

' Mbwazirume ' (Kawanda)—a medium tall clone with small, oblique to pendulous bunches and short spreading fruits; many persistent neuter hands; male bracts and flowers more or less persistent; male bud very large, fat, blunt, dark bluish-crimson. Leaf Spot slight. Type 58.

' Nambi ' (Kawanda)—a tall clone with freakish horizontal or oblique bunches of several hands; but with very few, large fruits in each; male flowers are also few in cluster and abnormal in form; male bud slender and acute. Leaf Spot slight to moderate. Type 45.

' Sindika ' (Kawanda)—a medium tall clone resembling the diploid type ' Bande '; bunch oblique with few hands, fruits slender, upturned, angular, bottlenecked; neuter flowers few, persistent; rachis naked; male bud rather large, dull red-purple. Probably the same as ' Muziranyama ' and ' Nyeru ' (Ankole). Susceptible to Panama Disease and Leaf Spot. Type 59.

' Kitarasa ' (Moshi)—a medium tall clone with compact oblique bunches, ripening dull, ochreous yellow; readily distinguished by the orange vascular strands in corm and fruits and by the orange-yellow, non-staining sap; petioles with reddish wings. Leaf Spot moderate. Type 46.

' Makifui ' (Moshi)—a dwarf clone rather resembling the short ' Cavendish ' types but with smaller, oblique to pendulous bunches on very short peduncles; first hands sometimes within the pseudostem; ripens greenish-yellow with yellowish aromatic flesh; petiole wings and

peduncle flushed with dull purple. Also ' Kiseri ilalyi ' (Moshi) and perhaps ' Mficha chana ' (Zanzibar). Type 49.

' Paji ' (Zanzibar) = ' Mzigo ' (Pemba)—a medium to short clone with red-flushed petiole margins; bunches oblique and untidy with rather few hands of longish spreading fruits; ripens yellow; texture and flavour fair. Leaf Spot slight. Type 57.

' Nakitembe ', an important Uganda clone, has been imported to Trinidad but it has grown poorly and no useful information is yet available.

AB and AAB groups—hybrid types

The identities of two types are thought to be too doubtful for inclusion in *Table 2*. They are:

' Kisubi ' (Kawanda)—a diploid AB type, possibly different from ' Ney Poovan ', Type 20, and said to be a recent introduction to Uganda.

' Yellow banana ' (Kawanda)—an alien AAB type, probably not synonymous with ' Silk ', Type 17, which it resembles, however, in its general aspect and in its susceptibility to Panama Disease.

CONCLUSIONS

The ' alien ' types may be quickly eliminated from consideration. Twelve have been noted and, of them, ten are known elsewhere in the tropics. Only ' Small Type ' and the ' Yellow Banana ' from Uganda are not identified with known forms. All but a very few of the names recorded for alien types in the inland regions are accounted for.

Table 5. Numbers and distribution of ' Native ' acuminata *types (AA and AAA)*

	Inland				*Coastal*			*Total* (5)
	Kenya	*Uganda*	*Bukoba*	*Total* (5)	*Tanganyika*	*Zanzibar*	*Total* (5)	
Total names (1)	21	72	14	107	33	13	46	153
Names interpreted (2)	9	18	4	31	12	11	23	54
Types recognized (3)	4	7	4	12	7	8	13	22
' Mutika–Lujugira ' group	3	4	4	8	2	—	2	8
Estimated total types (4)	8	20	8	25	16	10	20	40

NOTES: (1) Those reported by Baker and Simmonds (1952); at least 100 more are on record but cannot be interpreted for the purpose of this table.

(2) That is, names which can reasonably certainly be applied to a distinct clone, whether from evidence of I.C.T.A. introductions or the field notes.

(3) Total types grown at I.C.T.A. and proved to be distinct; including the ' Mutika–Lujugira ' group, which is shown separately in the next line.

(4) The Trinidad introductions undoubtedly include the greater part of the diversity seen by Baker and Simmonds.

(5) Allowance is made for types common to more than one area.

Among the ' native ' clones, 22 distinct *acuminata* types (AA and AAA) have been recognized. The distribution of these types and estimates of the total numbers of types in each area are shown in *Table 5*. From the information available, some 54 local names can be assigned to these 22 types. 29 of these local names seem to belong to eight widely grown triploid clones which are all, clearly or probably, derived one from another by somatic mutation (*Table 4*). It is certain that other synonyms exist for these sorts and not unlikely that further mutations are so far undiscovered. They are more or less limited in distribution to the inland localities (Kenya, Uganda and Bukoba); only two types and four of the 29 names are recorded from

the coastal belt (Amani, Moshi, Zanzibar). The existence of such a group of somatic mutants is further evidence for a very long history of cultivation in East Africa.

Of the remaining fourteen types, eight are diploid (AA) and all are found in the coastal belt, only one inland; six are triploid (AAA), either coastal or inland but not common to both. Thus, there is a marked lack of correspondence between the inland and coastal types, suggestive of two distinct migration routes or of two distinct periods of introduction.

Among these 22 *acuminata* types, only one is certainly known elsewhere in the tropics, on the evidence of our collections, of the literature, and of cultivations in Malaysia and Oceania examined by SIMMONDS (unpublished). The others may exist (or have once existed) in Madagascar or southern India, both areas in which the cultivars are yet rather poorly understood. If this should prove to be true for even a few clones, then the whole history of East African bananas would at once become much clearer and, conversely, much light might be shed upon the history of the crop in southern Asia. Indeed, ' Kari vazhai ' and ' Nalla chakkarakeli ' as illustrated in Jacob (1952) do show some resemblance to ' Lujugira '.

Among the hybrid types (AB, AAB, ABB) the situation is quite different, for only five are recorded as accepted sorts in native cultivations and one of those (' Kisubi ') is said to be a recent introduction. The others, and most of their somatic mutants, are identifiable with types known in Asian or other cultivations and it is unlikely that more than one or two additional types await discovery in East Africa. There is thus a striking contrast between the small group of well known hybrid cultivars and the considerable diversity of unfamiliar (possibly largely endemic) *acuminata* types. The inference is that the hybrid types are not part of the original assemblage but are of more recent adoption. This view is favoured by the facts of distribution of some of these sorts: ' Bluggoe ' is widely grown in the coastal zone but is very rare inland; ' Horn plantain ' is general and diversified by somatic mutation at the coast but the type form only is recorded for Bukoba and Uganda and there is no record from Kenya; ' French plantain ' (which may be represented in Kenya by ' Nyakahe ') is generally recorded but, again, probably exhibits more mutants in the coastal areas. All this is suggestive of the penetration of a predominantly *acuminata* cultivation by invading hybrid types spreading inland from the coast; the situation would seem to be analogous with that described for New Guinea by SIMMONDS (1956).

The total number of cultivars in East Africa was estimated by Baker and Simmonds to be about 70, represented by over 200 native names. More than half of these names have been considered above and 39 types have been mentioned. Since the clones introduced to Trinidad were intended to represent the greater part of the diversity present in East Africa, it is now concluded that the total number of types, excluding somatic mutants, is probably about 45, of which about 35 are accepted in native cultivations.

SUMMARY

(*1*) Fifty one East African banana clones were grown and compared with each other and with a standard collection at the Imperial College of

Tropical Agriculture. The results are made the basis for an analysis of the number of cultivars and their distribution in East Africa.

(*2*) There are probably not more than 55 cultivars in East Africa all told; a majority of them are types (diploid and triploid) that originated from *Musa acuminata* and very few of them are yet known outside East Africa. Other types (of hybrid origin) show signs of being of more recent introduction to the continent; they are all well known and widely distributed outside Africa. Somatic mutation has contributed much to diversity.

ACKNOWLEDGEMENTS

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REFERENCES

Baker, R. E. D. and Simonds, N. W. (1951). 'Bananas in East Africa. Pt I. The botanical and agricultural status of the crop.' *Emp. J. exp. Agric.* **19,** 283–90

— — (1952). 'Bananas in East Africa. Pt II. Annotated list of varieties.' *Emp. J. exp. Agric.* **20,** 66–76

Cheesman, E. E. (1948). 'Classification of the bananas. IIIc.' *Kew Bull.* **1948,** 145–53

Jacob, K. C. (1952). '*Madras Bananas*'. Government Press, Madras

Simmonds, N. W. (1954a). 'Varietal identification in the Cavendish group of bananas.' *J. hort. Sci.* **29,** 81–88

— (1954b). 'A survey of the Cavendish group of bananas.' *Trop. Agriculture, Trin.* **31,** 126–30

— (1956). 'A banana-collecting expedition to Southeast Asia and the Pacific.' *Trop. Agriculture, Trin.* **33,** 251–71

— and Shepherd, K. (1955). 'The taxonomy and origins of the cultivated bananas.' *J. Linn. Soc.* (*Bot.*), **55,** 302–12

Seasonal Variation of the Surface pH *Value of some Rice Soils of Sierra Leone*

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The pH value of some soils in which rice is grown by irrigation fluctuates during the growing season (Grist, 1953; Ponnamperuma, 1955). The phenomenon was first reported by Dennett (1932) who observed that the pH value of some Malayan rice soils fluctuated between 4·5 to 5·0 and 6·5 to 7·0 units under fallow and flooded conditions; in laboratory studies he observed a change of pH value from 5·2 to 7·1 units on flooding a soil for 5 days. Ponnamperuma records similar changes of pH value on flooding although in the three soil samples which he studied the changes were neither so rapid nor so pronounced as those reported by Dennett; the largest change observed in 8 days was 0·5 unit, and in 51 days 1·6 units.

In these studies emphasis was placed on the increase of the pH value under flooded conditions in irrigated soils. However, it is known that some swamp soils in Sierra Leone may undergo very large decreases of pH value if allowed to dry. The climate of Sierra Leone exhibits very marked wet and dry seasons: at Rokupr, the 20-year average of the rainfall from April to November is 114·06 in. and from December to March is 1·26 in. Under natural conditions in Sierra Leone, therefore, there is drying of the surface of some rice soils during the dry season and flooding during the wet season. If the drying were sufficiently pronounced, a fall in the pH value of the surface soils would be expected in some cases so that, if a rise of the pH value of a soil on flooding is a general phenomenon, seasonal fluctuations of pH value would be expected to occur at the surfaces of the soils. Such seasonal fluctuations of pH value might be as pronounced as those reported by Dennett and therefore of considerable practical importance.

Experiments have been made to investigate the existence of a fluctuation of pH value at the surface of some rice soils in Sierra Leone. The study was in two parts. In the first, the pH values at the surfaces of a number of small plots of soil, which had been cleared from mangrove vegetation for some years, were determined at monthly intervals for 32 months. In the second part of the study, the generality of the results obtained by the study of the small plots was investigated by determinations of the pH values of the surface soils of a recently cleared area of mangrove swamp of 250 acres extent. These determinations were made on two occasions at an interval of 8 weeks. In a subsidiary investigation, the levels of availability of some ions in the surface soils of the small plots were determined at monthly intervals for one year.

EXPERIMENTAL METHODS

The soils chosen for the monthly determination of surface pH value were part of the farm of the West African Rice Research Station at Rokupr,

Sierra Leone (9°01′N., 12°57′W.). They had been cleared from mangrove vegetation and used for the growth of rice for at least 50 years. The areas of soil used are immediately adjacent to the Great Scarcies River. The soils are sedimentary with a high clay content and are very dark brown or black in colour. They are cultivated annually to a depth of about nine inches, but below this layer undecomposed root residues may occur. There is a seasonal variation of the salt content of the river, but the fall of the content is very rapid at the beginning of the wet season, during which it remains low enough for a crop of transplanted rice to be grown without the exclusion of the river water.

The soils used for the investigation are those of an experiment which was started in 1946 to investigate the effect of different systems of water control on soil fertility. Four plots, each of about 0·1 acre, are subjected to different tidal influences. Three of the plots are enclosed by low bunds, with single wooden sluices, and are referred to as Polders 'A', 'B' and 'C', while the fourth, Reference Area 'D', is left unbunded. The influx of tidal water to the plots is controlled as follows:

Polder 'A': Tide excluded 15 June to 15 December (wet season); tide admitted 15 December to 15 June (dry season).

Polder 'B': Tide excluded 15 December to 15 June; tide admitted 15 June to 15 December.

Polder 'C': Tide always excluded.

Reference Area 'D': Tide always admitted.

In the present investigation, the surface soils of the plots were sampled at monthly intervals. Since there were indications of leakage through the sluices, the three polders were each divided into two parts for soil sampling purposes, the half adjacent to the sluice ('near sluice' in *Table 1* below) and the remainder ('away from sluice'); the Reference Area 'D' was sampled as a single unit. Surface soil samples were taken at 6 to 10 points within a sampling area and mixed as thoroughly as possible before sampling for analysis. The pH value of the soil was determined as soon as possible, and always within 24 hours of sampling, using a suspension of soil to distilled water of approximately one part to two. From December 1953 to March 1955, when laboratory facilities were limited, the determination of pH was made, after filtration of the suspensions, with chemical indicators, the probable error in the determinations being 0·2 unit. In the period May to July 1954, it was not possible to determine pH values in the range 2·8 to 3·6 units due to lack of a suitable indicator. From April 1955 all pH values were determined directly in the soil suspensions using a pH meter, the probable error in these determinations being 0·05 unit.

The levels of availability of the following ions were determined in four of the sampling plots: (total) iron, aluminium, manganese, calcium, magnesium, potassium, phosphate and chloride, for a period of 12 months. The determinations were made in extracts of the soil samples collected for the determination of pH value. The level of chloride was determined in water extracts, but those of the other ions were determined using normal ammonium acetate solution as extractant. The pH of the ammonium acetate extractant was adjusted to be within 0·2 unit of that of the soil sample

extracted by the addition of glacial acetic acid. The soil samples were stored in airtight glass bottles before extraction, and the extractions were made within 24 hours of the collection of the samples. The solutions were analysed by the standard laboratory procedures (see TOMLINSON, 1957a), potassium being determined flame-photometrically and chloride by titration with silver nitrate solution.

The area chosen for the investigation of the generality of the results obtained at Rokupr was one of two independent polders near Mapotolon in Samu Chiefdom, Sierra Leone. The polder is situated about 2 miles south of the border of Sierra Leone with French Guinea and about 2 miles from the sea (9°03′N., 13°17′W.). It has an area of about 250 acres and was completed during the dry season of 1952–53, since when tidal water has been completely excluded from it. Before completion of the polder most of the area enclosed was not cultivated and the vegetation was mainly low mangrove (*Avicennia nitida* and *Rhizophora mangle* with some *Rhizophora racemosa*, *R. harrisonii* and *Laguncularia racemosa*). Since enclosure the vegetation has been cleared but only some 20 per cent of the area was cultivated during 1954, the proportion rising to about 50 per cent in 1955. Surface soil samples were collected at known points within the polder on 1 to 2 May 1956 and again at the same points on 26 to 27 June 1956; 158 soil samples were taken on each occasion. The samples were stored in airtight glass bottles until examination. The pH values were determined in suspensions of soil and distilled water of approximately one part to two using a pH meter and were completed within 5 days of the collection of the samples. It was shown that storage of the soil samples for 30 days did not produce a change in the pH value greater than 0·5 unit.

EXPERIMENTAL RESULTS

(a) *Observations at Rokupr Farm*

The results of the monthly determinations of the pH values of the surface soils of the seven sampling areas of Rokupr Farm are presented in *Table 1*.

(b) *Observations at Mapotolon*

The two distributions of surface soil pH values of Polder 'B' of the Mapotolon Empoldering Scheme are most clearly shown diagramatically. *Figure 1* shows the distribution of pH values on 1 to 2 May 1956 and *Figure 2* shows the distribution of values on 26 to 27 June 1956.

(c) *Subsidiary experiment*

This experiment was preliminary in character. It was designed to investigate whether fluctuations of soil pH value are accompanied by fluctuations of the levels of availability of some ions in the soils. In those cases in which fluctuations of levels of availability were observed but could not simply be related to soil pH value, the cause of the fluctuations has not yet been investigated. For this reason the results of the experiment will not be given in detail but will be summarized.

The ions investigated, iron, aluminium, manganese, calcium, magnesium, potassium, phosphate and chloride, fall into four groups.

(*a*) No regular variation of the levels of availability of manganese (0 to 16 p.p.m., wet soil) or magnesium (0 to 400 p.p.m., wet soil) were observed.

(*b*) The levels of availability of (total) iron (0 to 6000 p.p.m., wet soil) and of aluminium (0 to 450 p.p.m., wet soil) depend simply on the soil pH value, rising when that value falls.

(*c*) The level of availability of phosphate (1 to 40 p.p.m., wet soil) depends primarily on the soil pH value, rising when that value falls, but there are smaller variations in the level of availability of this ion, which are not a simple function of the soil pH value.

Table 1. pH *values of the surface soils of Rokupr Farm sampling plots*

Date	*Polder 'A'*		*Polder 'B'*		*Polder 'C'*		*Ref. Area 'D'*
	near sluice	*away from sluice*	*near sluice*	*away from sluice*	*near sluice*	*away from sluice*	
3.12.53	6·3	6·9	6·1	6·0	5·6	4·3	5·8
2. 1.54	6·5	6·7	7·0	6·3	5·8	3·8	6·0
3. 2.54	6·8	6·1	6·2	6·0	4·8	3·9	6·3
3. 3.54	6·0	5·6	4·9	5·7	3·9	3·9	4·8
1. 4.54	6·0	4·2	5·4	4·9	3·4	3·4	5·7
12. 5.54	5·6	5·3	4·0	4·0	2·8–3·6	2·8–3·6	5·6
4. 6.54	6·0	4·5	5·4	5·3	2·8–3·6	2·8–3·6	5·6
3. 7.54	6·1	5·4	6·8	6·4	2·8–3·6	2·8–3·6	6·1
30. 7.54	5·3	5·4	6·5	5·3	4·4	3·2	5·2
17. 9.54	6·4	6·2	6·9	6·0	3·9	3·2	5·8
8.10.54	6·7	6·4	6·7	6·3	5·4	4·2	6·0
4.11.54	7·2	7·2	7·2	7·0	5·0	5·0	7·2
3.12.54	7·0	6·0	7·2	7·0	4·8	5·0	7·2
5. 1.55	6·8	6·6	6·6	6·8	4·2	3·8	7·1
7. 2.55	6·0	6·8	5·4	5·8	3·4	3·4	5·8
4. 3.55	4·4	4·5	4·6	4·2	3·6	3·6	6·1
2. 4.55	4·7	4·6	5·5	5·7	2·9	2·8	4·6
4. 5.55	4·8	4·5	4·2	4·9	2·7	2·8	3·8
4. 6.55	5·9	6·1	6·5	6·2	3·0	3·1	5·0
4. 7.55	6·6	6·5	6·8	6·6	4·5	3·2	6·4
3. 8.55	6·9	6·7	6·9	6·9	4·1	3·9	5·2
2. 9.55	6·6	6·5	6·5	6·5	4·7	4·1	5·9
4.10.55	7·0	6·9	6·6	6·6	5·9	5·1	6·5
2.11.55	7·0	6·8	6·9	6·7	5·4	5·3	6·9
2.12.55	6·9	6·8	6·8	6·6	6·2	5·5	6·0
3. 1.56	6·8	6·9	6·5	6·1	6·0	5·9	5·6
2. 2.56	5·5	6·4	6·3	5·9	3·9	3·6	5·8
2. 3.56	4·3	5·1	5·7	4·8	3·3	3·1	4·8
5. 4.56	4·3	3·3	4·8	4·8	2·9	2·7	4·5
5. 5.56	4·3	3·8	5·3	4·8	2·6	3·1	3.1
5. 6.56	3·9	3·6	4·8	4·5	2·6	2·7	3·9
2. 7.56	5·1	5·1	6·5	6·1	4·0	3·2	4·9

(*d*) There are fairly regular variations of the levels of availability of calcium (0 to 600 p.p.m., wet soil), of potassium (50 to 350 p.p.m., wet soil) and of chloride (40 to 2000 p.p.m., wet soil) which are not related simply to variations of the soil pH value. The variation of the level of chloride is related to the variation of the salinity of the adjacent river water, but the factors which control the levels of availability of calcium and potassium have not been investigated.

DISCUSSION

It is clear from the data presented in *Table 1* and in *Figures 1* and *2* that there is a seasonal fluctuation of surface soil pH value in the soils investigated. In the plots examined at Rokupr, the variation is of about 3 pH units in magnitude, the value being higher in the wet and lower in the dry

season. It will be seen from *Table 1* that the pH value of the surface soil of Polder 'C' is almost always less than those of the other sampling plots. This is a consequence of the total exclusion of tidal water from Polder 'C', but it should be noted that, in spite of the lower pH value, the surface soil of Polder 'C' exhibits the same type of pH fluctuation as do those of the other plots. Comparison of the pH values for Polders 'A' and 'B' shows that the period over which tidal water is admitted to the soils has little effect on the occurrence of the pH fluctuation.

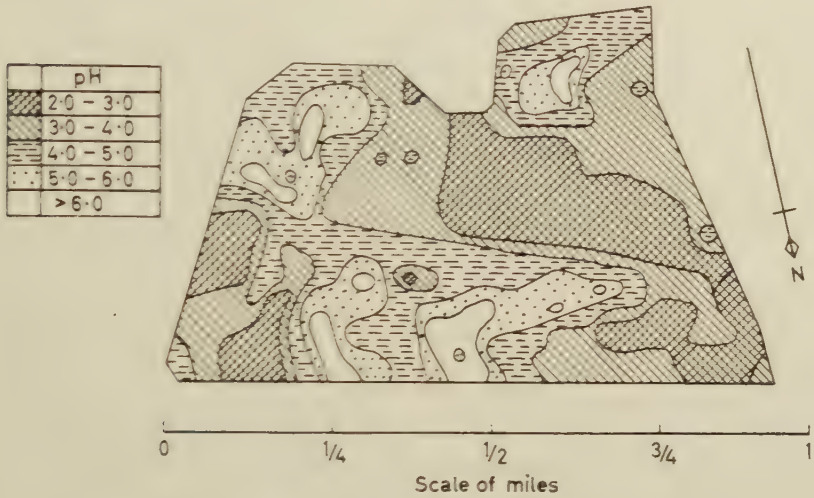

Figure 1. Distribution of surface pH *values. Mapotolon Polder 'B' 1 to 2 May 1956*

Comparison of *Figures 1* and *2* shows an overall rise of surface pH value in the area studied during the eight weeks between the collections of the two sets of soil samples. Of the 176 sites sampled on the two occasions, 93 showed an increase of pH value from 1 to 2 May to 26 to 27 June greater than 0·5 pH unit, 68 showed a change less than 0·5 pH unit in either direction, and only 15 showed a decrease of value greater than 0·5 unit. The overall rise of surface pH value is therefore well established. In some cases in which a rise of value was not found, inaccuracy of soil sampling may obscure a change, but it is probable that not all the surface soils of the area exhibit a large seasonal pH fluctuation. It will be suggested below that the rise of surface soil pH value at the beginning of the wet season may be due to soil leaching. The area studied is empoldered and, if soil leaching is of importance, acid substances leached from the higher parts of the polder would be expected to accumulate in the lower parts and to maintain the surface soil acidity there. In agreement with this suggestion, an increase of surface soil pH value was not observed in most of the lower areas of the polder. In addition to this factor, not all swamp soils show a large seasonal fluctuation of surface pH value. Surface soils of Rokupr Farm which did not originally carry mangrove vegetation have been sampled at monthly intervals for one year. A large fluctuation of surface soil pH value was not observed. There may be a smaller seasonal fluctuation of about one pH

unit in magnitude but the observations are not yet sufficiently extensive to establish such a variation with certainty. In the case of the polder studied at Mapotolon, some of the area did not carry mangrove vegetation before clearance (the original distribution of vegetation has been reported in a previous communication, *Figure 1*; TOMLINSON, 1957b) and a large seasonal pH fluctuation may not therefore be a property of all the surface soils.

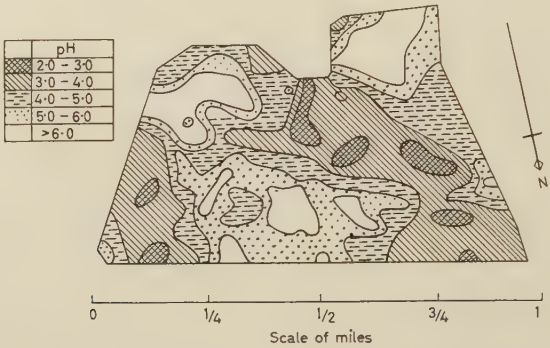

Figure 2. Distribution of surface pH *values. Mapotolon Polder 'B' 26 to 27 June 1956*

The experiments were designed to show the existence of a seasonal fluctuation of soil pH value and only a few preliminary experiments to determine its cause have yet been made. For that reason the explanation advanced here can only be regarded as a tentative one. In previous studies emphasis has been placed upon the rise of soil pH value on flooding. Ponnamperuma (1955) suggested that the increase of pH is due largely to the production of ferrous and manganous hydroxides on flooding and Dennett (1932) suggested that the pH fluctuation is due to oxidation and reduction of ferrous and ferric ions and that ferrous hydroxide might act as a base in soils of high pH value. It would seem more likely, however, that the very large seasonal pH fluctuation which we have observed depends upon the presence in the soil of compounds, the oxidation products of which are acidic. From previous studies (see e.g. Tomlinson, 1957a) such compounds are known to be present in these soils and their oxidation is known to be rapid. There is some evidence that the reduced compounds concerned are sulphides, the content of which in the soils may be very high: a sample of an uncultivated and permanently waterlogged soil at Rokupr has been shown to contain 0·1 per cent by weight of dry soil of this ion.

If the fall of soil pH value during the dry season is a result of the accumulation in the soil of acidic oxidation products, the rise of the value during the wet season may be due either to removal of the oxidation products or to their reduction, or in part to both these factors. In a laboratory investigation, a soil sample of pH value 2·8 units was waterlogged, but no rise of the pH value could be detected after 2 months. It is unlikely therefore that the reduction of the oxidized compounds to non-acidic forms is very rapid. However, the reduction may be more rapid in the field than in the laboratory due to the presence of oxidizable residues of the rice crop [REED

and STURGIS (1939) have reported that the pH value of flooded rice soils tends to rise in the presence of organic matter] and to other factors such as the availability of suitable reducing bacteria. Our laboratory observation is in contrast with those of Dennett and Ponnamperuma, reported above. This may be a result of the very low pH value of our soil sample. The scale of pH is a logarithmic one so that an increase of pH value from 3 to 4 units is a decrease of acidity 100 times as great as that of an increase of pH value from 5 to 6 units. Moreover, it is possible that the very low soil pH values influence the activity in the soils of micro-organisms, through the agency of which the reductions may take place.

The effect on its pH value of leaching an acid soil has been investigated in the laboratory and it has been shown that leaching leads to an increase of the pH value. This indicates that the acidic compounds present are water-soluble and suggests that soil leaching is an important factor in the increase of surface soil pH value which is observed in the field during the wet season. It has been suggested above that movement of acidic compounds in this way is of importance in determining the changes of surface soil pH value in the lower parts of the polder studied at Mapotolon. However, if we assume that the reduction of the acidic compounds is as slow in the field as in the laboratory, the greater part of the compounds cannot be leached completely from the soils during the wet season but must remain available for re-translocation to the surface of the soil during the subsequent dry season. The experiments at Rokupr were made with soils which have been used for the growth of rice for at least 50 years and it is unlikely that the soils still contain reserves of reduced compounds a part of which can be oxidized each year to replace acidic compounds which have been leached completely from the soils. It is suggested therefore that the seasonal fluctuation of pH value at the surface of the soils depends upon translocation of acidic compounds to and from the surface during the dry and wet seasons. Oxidation and reduction of compounds in the soils seems to be of lesser importance but this conclusion is based on the results of preliminary laboratory investigations only.

There are at least two important consequences of the phenomenon reported. The soils of this type which are cultivated in Sierra Leone are used for the growth of transplanted rice seedlings, the time of transplanting (from June to September) usually being dependent on the salinity of the soils. However, it has been shown (Tomlinson, 1957a) that rice seedlings do not survive if transplanted into soils of pH value less than about 3 units and make poor growth unless the pH value is greater than about 5 units. If the pH value of the surface soil fluctuates through these values therefore, the time of transplanting of the seedlings may be of great importance. An experiment designed to investigate this is now in progress at Rokupr. A second consideration of some importance concerns soil sampling for analysis for fertilizer advisory purposes. The subsidiary experiment which was made in this study has shown that, particularly in the case of phosphate, the fluctuation of surface soil pH value would complicate seriously the assessment of the fertility of the soils by analytical methods. Careful account must be taken of the time of soil sampling if attempts are made to assess the fertility of the soils by these methods.

SUMMARY

The pH values at the surfaces of some small plots of rice soils have been observed at monthly intervals for 32 months. The generality of the results obtained has been investigated by determinations on two occasions of the pH values of the surface soils of a large area of recently cleared mangrove swamp. A seasonal fluctuation of pH value at the surface of some of the soils has been observed. The pH value rises during the wet season and falls during the dry season and in some cases the magnitude of the fluctuation is as great as 3 pH units. It is suggested that the fluctuation is a result of translocation to and from the soil surface of water-soluble acidic compounds.

It has been shown that the fluctuation of soil pH value is accompanied by fluctuations in the levels of availability of iron, aluminium and phosphate in the soils. Attention is drawn to the importance of this in sampling the soils for fertilizer advisory purposes and also to the importance of the fluctuation of soil pH value in the choice of the time of transplanting rice seedlings into the soils.

ACKNOWLEDGEMENTS

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REFERENCES

Dennett, J. H. (1932). 'A preliminary note on the reaction of paddy soils'. *Malay. agric. J.* **20,** 518

Grist, D. H. (1953). *Rice,* p 9. Longmans, Green & Co., London

Ponnamperuma, F. N. (1955). 'Some aspects of the chemistry of rice soils'. *Trop. Agriculturist* **111,** 92

Reed, J. F. and Sturgis, M. B. (1939). *Bull. La agric. Exp. Sta.* 307

Tomlinson, T. E. (1957a). 'Changes in a sulphide-containing mangrove soil on drying and their effect on the ability of the soil to support the growth of rice'. *Emp. J. exp. Agric.* **25,** 108

— (1957b). 'A relationship between mangrove vegetation, soil texture and reaction of surface soils after empoldering saline swamps in Sierra Leone'. *Trop. Agriculture, Trin.* **34,** 41

Palm Wine in Libya

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The method of tapping the date palm (*Phoenix dactylifera* L.), employed in North Africa whereby the stem is tapped, is quite different from those methods used for tapping the coconut, palmyra, and caryota in Travancore, whereby the sap is collected from the spathe; and again the method of tapping the wild palm, *Phoenix sylvestris* Roxb. in the Sundarbans, although it is the stem and not the spathe that is used, differs considerably from that employed for the cultivated date palm in North Africa.

When the writer was in the Sundarbans he was impressed by the skill with which the tappers there tapped *P. sylvestris*. Their method permitted tapping to be annual, some palms being tapped continuously for more than fifty years, whereas in Libya the tapping of *dactylifera* is practised not more than four or five times in the palm's life. Also tapping began at a much earlier age of the palm in India than in Libya. Furthermore, there was no mortality amongst the tapped palms in Bengal, whereas in Libya it may be five or six per cent. On the other hand, the season's yield of sap in the Sundarbans was much less than that obtained in Libya. On balance, however, it seemed that a comparison between the methods employed in the two countries might lead to an improvement in tapping in Libya. The suggestion, therefore, was made to the Administration of Tripolitania that an Indian tapper be brought to Libya to demonstrate his method.

This suggestion received support from another, which was that the Indian tapper should also demonstrate making sugar from palm sap, an art unknown in Libya.

These suggestions having been agreed to by the Administration of Tripolitania, the Government of West Bengal was approached and was so kind as to grant permission for the State Palm Gur Organizer, Mr J. R. Sen, accompanied by a Bengali tapper, to visit Libya; and, in order to permit Mr Sen to be able quickly to understand Libyan methods of tapping, the following note was prepared.

Description of lagbi

In Tunisia palm sap is called *lagmi*, in Libya *lagbi*, in Egypt *lajbi* (though there the word is pronounced as in Libya). None of the variants of the word is to be found in any of the writer's Arabic dictionaries, but it possibly, or even probably, is derived from the verb, *lajjaba*=to cut. The name *lagbi* is applied both to the fresh sap (*lagbi halu*) and to the fermented liquor (*lagbi meiyit*). Belgrave says palm sap is called *lubki* in Siwa.

Date-palm sap, *lagbi*, is a whitish liquid, resembling barley water or what is known in Europe as coconut milk, the coconut water of the South Seas. The taste as it issues from the palm is sweet and much like that of fresh sugar-cane juice. Mamoli likens it to that of the small white wines

(*torborin*) of Milan, which are drunk fresh. *Lagbi* consists of about nine tenths water and one tenth sugar, almost all sucrose. In famine years in the Fezzan *lagbi*, although it is never used there for making solid sugar, may be the cultivator's only food. Possibly also it provides him with the vitamins in which his other food may be presumed to be lacking. The drawer of water (*jabbaar*) reckons to be kept supplied with *lagbi* by the proprietor. As the Arabic proverb has it, *Makilat Fezzan 'aguul wa jummaar wa lagbi* (The Fezzani's food is camel thorn, palm cabbage, and *lagbi*).

Lagbi ferments rapidly. The morning's collection by evening will contain four to five per cent alcohol (by volume). It then is slightly acid, has a pleasant tang, and tastes somewhat like a 'John Collins'. Nachtigal says that *lagbi* continues to ferment in the stomach causing discomfort but that the Arabs appear not to mind it.

Producing countries

Algeria, Tunisia and Libya are the three countries where the practice of tapping the date palm for *lagbi* is widespread. The writer has not so far found a reference to palm tapping in Morocco, nor does he remember noticing the practice on his visits there. An official of the Government of Egypt, who is now Deputy Director of Agriculture in Tripolitania, and who owns date property in Egypt, states that he has not heard of the practice in Egypt; but there are several references to it there in the literature. It would therefore seem to be safe to state that if tapping is practised in Egypt it cannot be widespread, though in the oasis of Siwa Belgrave reports that the practice is very common. It may be said that the practice is common only in the three central countries of N. Africa. For *lagbi* in Cyrenaica see Mamoli.

Lagbi and religion

It may be thought strange that an industry, whose product is chiefly consumed when it is strongly alcoholic, should be permitted to flourish in three Muslim countries, in a community to which alcohol is forbidden by its sacred law. Possibly tapping, being practised long before the Arab conquests, for which there is abundant evidence in the records of ancient Egypt, had become so firmly established amongst the date cultivators that central authority, generally only slight in the provinces, failed to exterminate it.

The doctors of the law pronounce sweet *lagbi* lawful: only when it has fermented is it forbidden. Some of them thus consider *lagbi* lawful for six hours after it is taken from the palm, but even after so short a time there may be much alcohol in it, especially in the evening's collection, due partly to the accumulation of ferments on the sticky palm heart and to the absence of washing or other ways of cleansing the collecting jars. It is probable, indeed, that there is very little *lagbi* as ordinarily collected which is completely free from alcohol. Lethielleux (1948) states that the doctors of the law consider *lagbi* lawful only (*a*) during the first two or three hours (after collection ?) and (*b*) after three days, when it loses its noxiousness and is called *kiras* (*sic*) (? from *gaaris*=sour), but in Tripolitania this word is used for 'fermented'.

LAGBI IN LIBYA

Number of palms tapped

On 9 November 1954 the Legislative Assembly approved the tapping of the following numbers of palms:

Tripoli Province	2000 palms
Eastern Province	1000 palms
Central Province	500 palms
Total	3500 palms
Possibly illicit tapping would account for	500 palms
Making a grand total for Tripolitania of	4000 palms
A guess would be that there are as many again in the Fezzan, making possibly in all for the two provinces of Tripolitania and the Fezzan	8000 palms

The writer has no information as to the number of palms tapped in Cyrenaica.

Morgantini states that the Government of Tripolitania limited the number of individual palm licences for tapping to between 3000 and 4000 annually for the years 1931 to 1935. Four thousand is a number frequently mentioned as that of the tapped palms on the coast of Tripolitania. As the number of palms on the coast is commonly thought to be about one and a half million, the proportion of tapped palms to the total may be about 2·7 per thousand. It has been said that in Italian times Government regulated the issue of licences so that the proportion of tapped palms to the total should not exceed 4 per thousand. In recent years, as the consumption of *lagbi* is believed to have decreased owing to the departure from the country of large numbers of Italians and Jews, it is likely that the proportion of tapped palms has fallen. A rate of 3 per thousand per annum does not appear unreasonable from casual inspection in the gardens.

Licence

General—In Turkish times, that is up to 1911, as palms tapped for *lagbi* were taxed, some kind of licence must have been required, but the writer has not been able to learn its nature or how it was obtained. On 30 March 1913, however, the Italian Government of Tripolitania issued *Decree No 292* regulating the extraction of *lagbi*, and by 1937 licensing had extended to the Fezzan, although by that year the system could not have been more than just introduced because the number of licenses issued was only about 100. There is now no licensing system in force there, nor was there in the oases of Gialo even before they were transferred to the Fezzan in May 1957.

No information is available as to the amount of illicit tapping in Tripolitania, but that there is some is certain because *lagbi* can be obtained out of season and the control of tapping by the peasant for his own use is difficult. That part of the coastal belt of date palms where illicit tapping is most common is that which lies west of Sormaan, including El-Ujeilaat. The first licences in 1957 were issued on 22 May.

The Decree of 1913—The decree consists of the following twelve articles:

Art. 1. *Permit Required.* A permit to tap is necessary.

Art. 2. *Tax to be Imposed.* A tax of 40 l. is to be paid on each palm tapped.

Art. 3. *Kind of Palms to be Tapped.* Only those palms may be tapped that are diseased, or declining, or low yielding, or whose dates are poor.

Art. 4. *Issuing Authority.* Before tapping the *nulla osta* (written permission) must be obtained from the *Imaam* (Assistant Headman) of the village, attached to the owner's application, and sealed by the *Mukhtaar* (Headman).

The sealed *nulla osta* must then be presented to the *Mudir* (Deputy Assistant Commissioner of the district) for his visa or seal, who will forward the document to the authority competent to issue the permit.

Art. 5. *Tapper.* The application must bear the name of the intended tapper, who must be one of those whose name is on the register of tappers. Each *mudiriiya* (the district or office of a *Mudir*) must maintain a register of approved tappers, reviewed annually, and available to the public.

Art. 6. *Tax to be Paid.* Tax must be paid before the permission is issued.

Art. 7. *Sealing Palm.* Round each licensed palm must be put a wire sealed together with a lead seal. The *Mudir* is to appoint a person to do this. The cost of wiring is to be borne by the applicant.

Art. 8. *Period.* No palm may be tapped for more than 60 days. The period may be shortened to 40 days if the *Mudir* thinks the longer period will damage the palm.

Art. 9. *New Planting.* The owner must plant a new palm for every one tapped, in the same garden the same year.

Art. 10. *Responsibility for Execution. Imaam, Mukhtaar,* and *Mudir* are all responsible for seeing that the provisions of this decree are observed.

Art. 11. *Contravention.* Contravention is punishable by a month's imprisonment or by a fine of 100 l. as well as by the confiscation of the *lagbi* and implements. Both owner and tapper are subject to the same penalties.

Contravention of Art. 9 is punishable by a fine of 30 l. The obligation to plant as soon as possible remains.

One tenth of the fine goes to the informer.

Art. 12. *Responsibility for Observance.* Administrative Officials, *carabinieri,* customs guards, public security forces, and all persons in authority are charged with ensuring the observance of this decree.

Present method of obtaining licence—

(*i*) Owner and lessee agree on lease.

(*ii*) Owner obtains note of no objection from the *Sheikh* of his *Qabiila* (tribe), *Imaam, Mukhtaar* and *Mudir.*

(*iii*) It is generally the lessee who takes the combined no-objection certificate to the office of the *Mutasarrif* (District Commissioner).

(*iv*) Lessee takes appropriate document from the *Mutasarrifiiya* (office of the *Mutasarrif*) to the Tax Office.

(*v*) Lessee takes Tax-Office receipt back to *Mutasarrifiiya* and obtains licence.

(*vi*) Lessee or owner takes licence to the *Mudir,* who instructs policeman to accompany owner to the palm, which he seals.

(*vii*) At the end of the permitted period the policeman removes seal, and further extraction of *lagbi* is forbidden.

Tax

Minutilli, writing in 1901, states that the tax in Tripolitania amounted to the equivalent of 25·4 lire a palm and that the total tax collected was believed to be 80,000 lire. This tax thus brought in 2·8 per cent of the total revenue of the *wilaiyat,* if the contributions made direct to Constantinople be ignored.

It will be observed that if the data for tax per palm and total tax collected are more or less correct then the number of palms taxed would have been about 3150.

As has already been noted, the tax in 1913 was 40 l. (=£L 1600 at 25 l.=£1) plus costs, etc. In the Fezzan in 1937 it was 125 l. (=£L 1·316 at 95 l.=£1). One Libyan pound (£L 1·000)=£1. 0. 0 sterling.

Today in Tripolitania the tax is:—

Tax £L 1·700
plus stamps on documents
plus stamp duty
plus cost of policeman's visit to palm.

There is no excise on *lagbi*.

Hire of palm

The owner of a tapped palm may be himself both cultivator and tapper, but round about the string of Tripolitanian coastal towns and apart from the more remote districts the usual procedure is for the owner to lease his palm for the season to a middleman or direct to the barkeeper (*barnaji*—a nice combination of French and Turkish). The amount of the hire, which includes insurance against death of the palm, though of course no actual insurance policy is ever taken out, varies from £L 3·500 to £L 4·000 for those varieties of palm whose yield is low to £L 6·000 to £L 7·000 for those whose yield is high.

Varieties of palm used

On the coast of Tripolitania the commonest variety of date is the Bikraari of which perhaps three quarters of the palms consist. The other two important varieties are the Taabuuni and Beiyuudhi. The number of palms of each of these perhaps amounts to 5 per cent.

The variety which is considered to yield the greatest amount of *lagbi* is the Taabuuni, the next the Limsi. After them come Bikraari and Beiyuudhi. Males are placed between Taabuuni and Limsi. Trotter states that the Bikraari gives the best *lagbi*, and the writer has heard this confirmed by local people. *'Aami* (that is to say seedlings) varying, of course, amongst themselves greatly in all their characteristics, are unpredictable in their yield, but on the whole they are considered poor producers.

It is said that palms with gracefully bending fronds, that is *rutub*, soft or yielding, give more *lagbi* than those with fronds upright and stiff (like those so many seedlings have).

Method of tapping

General—Two methods of tapping are described in the literature, one in which the crown of the palm is cut off and a cavity scooped out of the horizontal cut surface of the trunk, and the other the exposure but not the cutting-off of the terminal bud (the 'heart' or 'cabbage', Ar. *Jummaar*, Berber *Azaruz*) and its subsequent paring and the excavation of a circular trough around it.

The writer would be inclined to doubt the existence of the former method since Blatter's mention of it (1926) appears to have been taken from Fischer (1881), who appears to have taken it from Cosson and Jamin (1855),

who took it from GUYON, were it not that SHAW (1738) describes it in Tunisia in some detail and that PAOLETTI (1912) gives a circumstantial account of it in Egypt. He states that the cavity scooped out of the top of the palm may be as much as fifty centimetres deep. It would seem likely that this method is employed on palms that were due for felling in any case.

The writer has seen a third method employed in the Fezzan intermediate between the two others. In this the whole crown of the palm is not cut off but the fronds on one side are removed and a cavity is excavated in the side of the terminal bud sloping downwards, in which the sap is collected and from which it is baled out. Such treatment may be presumed to kill the palm, but, as it was seen practised only on the stunted shoots that crowd together in semi-wild thickets, which anyway need thinning, the practice causes no loss to the economy of the province.

Figure 1. P. dactylifera. *Close-up of the palm crown, showing the conical, white, palm heart* (Jummaar) *in the centre surrounded by a circular depression* (Haudh), *the spout* (Gattaar) *made of the midrib of a palm frond, and the sharp, small sickle* (Hajjaama) *used. Suuq el-Juma'*

The only method of extraction employed on the coast of Tripolitania and the only one of commercial importance is the second method. This now needs to be described in some detail, but, first, it should be added that the writer has heard of what is called the Zliten method, though he has never seen it employed, nor does he know anything about it save that the incision is said to be made at the side of the heart instead of at its apex and that it is uncommon because with it the yield of sap is low.

The usual method—(i) *The first cut.* All the central fronds are cut off at a point as near as possible to their base. The outer circle of fronds is allowed to remain in order to provide a platform on which the tapper can stand or

squat while working. The conical terminal bud is now exposed, care being taken not to cut into it. Around the tip of the cone a circular cut or trough (*haudh*), perhaps ten to twenty centimetres in diameter, is made. A sloping spout is inserted in the channel to carry the sap to the earthenware jar placed below to receive it. This spout is cut out of a palm frond or a frond base and is attached to the palm at its upper end by a palm-spine pin (*silla* or *shauka*).

The whole of the bud is now protected from the sun, which otherwise might kill it, by being covered with an inverted basket which has a hole in its bottom to accommodate the growing point as it grows up. Over the basket an old sack or some rags are placed.

(ii) *Daily attention.* There is no period of eight or twelve days waiting after the first cut has been made as there is in India with the ' wild ' date palm. Twice daily, in the early morning and the late afternoon, beginning on the day after making the first cut, or on the next day or the one after that, two operations are performed, the emptying of the receptacle and the shaving of the bud.

The receptacle is not often changed, and the *lagbi* is merely poured into another jar which is lowered to the ground on a rope. If the jar is changed it is only rinsed in water and never partially sterilized as it is in India. This is natural because the Arab wants alcohol while the Indian wants sugar. Indeed, the Arab frequently leaves a little of the previous collection in the pot as a starter for the new sap.

The operation of shaving is performed with a very sharp and tempered knife with a slight hook at its end. A shaving, only as thin as a sheet of paper, is taken off the whole of the exposed surface of the bud above the encircling cut. The shaving begins at the cut and is continued upwards.

The bud continues to grow upwards, slowly at first and faster later. As it grows up and as the trough descends it is necessary to lower the encircling *haudh* or cut. This is done by shaving its lower surface every four or five days. The spout has to be lowered correspondingly.

The normal rate of growth of a date palm in the summer is about a millimetre a day, so that in a forty-two day tapping period the total growth would probably be not more than four or five centimetres. However, one tapper told the writer that he has known the palm heart to grow up half a metre in a season.

Implements used

(a) *Cutting knife* (*Hajjaama*)—This costs £L 0·500. It is considered that its life is about one season. Tappers usually have several knives so that some can be sharpened while the others are being used. Sometimes the local tempering is defective and the knife may break in two.

(b) *Spout* (*Gattaar*)—Made by tapper.

(c) *Basket* (*Mamama*)—For covering the bud. Made of esparto grass.

(d) *Jar* (*Abaar*)—For collecting the *lagbi*. Also for lowering *lagbi* to the ground. This is the big one holding 21 to 22 litres. The smaller one, for use with low-yielding palms, of 15 to 16 litres capacity is called *fakhriiya*. Red pots are preferred to white ones because they sweat less.

(e) *Rope*, (*Habl*)—1·5 metre, bought in the town, for tying the jar to the tree. A sufficient length for lowering the *lagbi*. Rope of palm fibre (*liif*) is not used.

(f) *Demijohn* (*Mazaana*, presumably a corruption of the Italian *Damigiana*) —Has wicker protection. Capacity 50 l.=25 two-litre Chianti flasks (*fiasco*)=100 half-litre mugs (*taasa*) as served to customers in the bars. This and the following are provided by the contractor or barkeeper.

Figure 2. Mas 'uud bin Farj el-Muhdi descends the Hamraiya. Madwein

(g) *Funnel* (*Mahgan*)—For filling demijohn. No climbing rope or belt is used, but foot holes may be made if the trunk is tall and smooth.

Season of tapping

The best time for tapping, that is to say the time when the flow of *lagbi* is at its most abundant, is in early and mid summer from May to July, but there is abundant yield all through the hot weather. In winter the yield is small.

No licences were issued this year until *Ramadhaan*, the Muslim month of fasting, had ended on 29 April. This, however, is not a fixed date, because the Muslim year is a lunar one, so that according to the solar calendar *Ramadhaan* ends every year eleven days earlier than in the one before. What will be Government's attitude to tapping when *Ramadhaan* in some years to come falls in the middle of the season remains to be seen.

No licences are issued after the end of October, so that, as this month draws to a close, there is a spate of applications from those who wish to

continue legal tapping as long as possible, that is until 11 December, forty two days from the last day of October.

Duration of tapping

As already stated, legally at present and for the past three years no palm may be tapped for more than six weeks, and as has been seen from the decree of 1913 the Italian limit was 60 days. Tappers, however, say that before the present government came into power the limit was 70 or 75 days. It may be, therefore, that the earlier limit was later extended. They also say that a vigorous palm may continue to be profitably tapped for even as much as 120 days.

Figure 3. Phoenix dactylifera, *L. Effect of* lagbi *tapping. Rutbi palm on left, Rushdi on right. Gabes, Tunisia*

Frequency of tappings

Since the date palm is a monocotyledon and there is no meristematic layer surrounding the stem to repair damage, the Libyan way of tapping leaves a permanent constriction round the trunk of the palm, so that by counting the number of constrictions on a stem one readily perceives to how many tappings the palm has been subjected. The writer recalls having seen only once as many as six constrictions on a palm. Amongst tapped palms one with five constrictions is rare, with four common, but perhaps most show only two.

The period that elapses between tappings may thus be seen to be considerable. In any case at least five years would elapse between consecutive tappings, though Kralik says the operation can be repeated after two years.

Effect on palm

No dates are produced the year the palm is tapped nor the next year. The third year the yield of dates is small but by the time the fifth is reached the palm has returned to normal. It follows, therefore, that if the palm is valued for its yield of dates the process of tapping is necessarily harmful. On the other hand the writer has not found definite evidence that, if the palm does not die immediately after tapping, its life will be shortened; but it must be admitted that a tapped palm is more likely in a high wind to break off at the constriction than is a normal palm to be blown down. Such fracture, however, does not appear to be common.

The palm of course suffers a shock by tapping and as has been mentioned ceases to grow normally for a short while.

It is commonly said that 5 to 6 per cent of tapped palms die, but a skilful tapper may have 97 to 98 per cent successes. Minutilli states, however, that only 2 to 3 per cent of the palms live. Possibly *sopravvivono* (they live) is a misprint for *muoiono* (they die).

Tappers appear to consider the palm is not much, if at all, affected by the length of the tapping period, and on the other hand to consider that whether a palm lives or dies is entirely, or almost entirely, dependent on the skill of tapper. Tapping is a delicate operation, and the tapper who is too fond of his own product has many dead palms.

The tapper and his wages

Professional tappers are not organized into a guild, although in Italian times they were considered to be more or less under the control of their Syndic (*Amiin*), but nowadays the title only remains, and its present holder, an old man named 'Ali bin Maiyuuf, appears to have no authority over the other tappers.

The number of professional tappers is not known. If the number of licensed palms on the coast of Tripolitania be really about 3500, and if the average number of palms one tapper can manage be between fifteen and twenty then the number of tappers might be about 200.

The tappers, who bear the title of *Usta*, a corruption of *ustaadh*=professor, and now used for master carpenters, master masons, and other artisans, not being plentiful, their work being skilled and seasonal, and the profits on the extraction of *lagbi* being high, are highly paid.

Four methods of payment are employed, daily wages, so much a palm tended, so much a litre of *lagbi* extracted, and in kind.

Daily wages are about £L 0·700 to £L 1·000 a day.

By the palm the tapper receives £L 4 to 5, if he pays for his implements and the sharpening of his knives, and £L 3 to 4 if those expenses are borne by the lessee of the palm.

If payment is by the litre, the tapper receives about £L 0·020 if he bears the cost of implements and sharpening, and about half that if the lessee bears it.

In kind the tapper takes about one fifth. If he sells his fifth, say 2 litres, to the barkeeper at 3½ PT. per litre, his daily earnings per palm might be about £L 0·070.

On the basis of the above rates the tapper's earnings in the season might be somewhat as follows:

	£L
Daily pay (£L 0·850 a day × 42 days)	
Expenses on lessee	35·700
By the palm (17½ palms)	
(*a*) Expenses on tapper	78·750
(*b*) Expenses on lessee	61·250
By the litre (10 litres × 2 PT., 17½ palms)	
(*a*) Expenses on tapper	147·000
(*b*) Expenses on lessee	73·000
In kind (2 litres × 3 PT., 17½ palms) . .	44·100

It will be seen that there are wide differences in the earnings of the tapper calculated by the different methods. The man on daily pay presumably will work little and so his pay is low. The most risky way from the tapper's point of view of calculating the reward is by the litre and, as might be expected, the reward, if the yield in fact does amount to as much as, or more than, 420 litres in the season, is correspondingly greater. It might also have been expected that the reward in kind, being equally speculative, would have been equally well paid. What may be the reason for the discrepancy is that payment in kind is the only one in which the tapper actually sells his own product to the barkeeper and so has the opportunity of adulterating it and thereby increasing his reward, an opportunity of which advantage is widely taken.

Further inquiries must be made into the large difference in the reported remuneration when it is by the litre between that received by the tapper when he pays for implements and sharpening and that received when the lessee pays for them. £L 73·500 seems much too large a difference. One of £L 17·500 as in the case of payment by the palm seems much more reasonable.

Yield and production

Yield—(i) *Literature*. The following estimates of yield have been published:

	Litres	
	Average	Maximum
Minutilli . .	10	20
Lethielleux . .	7–10	—
Morgantini . .	8	—
Trotter . .	5–7	10–12
Cauvet . .	—	8

(ii) *Tappers*. Tripoli tappers make the following estimates:

	Litres
Usta El-'Ariifi	
Very big, very vigorous Taabuuni	50
Big, vigorous Taabuuni	40–50
Vigorous male	40
Bikraari, 'Aami, etc.	20–25
Usta Shaara'	6–35
Usta Sugheiyir	14–24
Amiin 'Ali	10
Usta Imhimmid	8–10

(iii) *Department of Agriculture.* Sig. Parrini has informed the writer that one season a certain vigorous palm growing close to a water channel in the Sidi Mesri Agricultural Experiment Station gave 1212 litres. If the season in that year lasted sixty days the average daily yield would have been 20 l. This is the only record so far found of an actual measurement of volume.

From the foregoing it would seem safe to assume, until actual measurements have been obtained, a yield of ten litres a day. Mr Barreveld hopes to obtain actual measurements this season.

Production. Morgantini gives an estimate of 15 to 20,000 hectolitres, from 300 to 400 palms at 500 l. per palm. This appears to be reasonable. If it were correct and if there were about 800,000 people in Tripolitania then the annual consumption per head would be a little more than 2 l.

Price, Return, and Total Value

Morgantini in 1938 gave the price as 50 to 60 lire per hectolitre, say 5·5 lire or £L 0·044 (at 125 lire to the pound sterling, which is the equivalent of the Libyan pound) per litre.

Today *lagbi* is sold in the bars at £L 0·060 per litre. The barkeeper buys it from the contractor or owner of the palm at prices ranging from £L 0·030 to £L 0·050, the lower prices being for the product already adulterated with sugar and water. Probably most *lagbi* is sold to the barkeepers at £L 0·035.

At this price the total value of *lagbi* in Tripolitania to the agriculturist might be put at about £L 6125 and the retail total at £L 10,560.

The unfermented *lagbi*, produced for the first few days of tapping before the weather has become hot and before the cut surface of the palm hearts and the jars have grown their cultures of ferments, is sold in the streets at £L 0·030 per litre.

Transport

Bicycles are much used for carrying the earthenware jars of *lagbi* from the gardens to the towns, and one sees on the roads no mean exhibition of trick cyclists, themselves and their machines draped with half a dozen heavy, fragile, dangling jars.

Larger quantites than can be carried on bicycles are conveyed in hand or donkey carts from the gardens to the main road, or even right to the bar if the haul is short. For long hauls lorries are used.

Transport costs might amount to about £L 0·005 per litre.

Adulteration

Lagbi is widely adulterated with sugar and water. The water increases the volume and the sugar, started by the ferments in the juice, is quickly converted into alcohol, so that the diluted juice is no less alcoholic than that which has not been treated.

Clientele

As has already been suggested, *lagbi* may be considered a part of the normal diet of the Fezzani cultivator, who claims to be incapable without it of the long, arduous drudgery of drawing water under a fierce sun. Also, on the coast of Tripolitania and Cyrenaica *lagbi* is commonly drunk by the cultivators. In the towns it is the drink of the poor working man and of the

disreputable section of the people. As Nachtigal noted eighty years ago, so today it is in the lupanar quarter of Tripoli town that most of the bars are to be found even though that quarter has moved from the mat huts of the negro suburb on the old Mushiir plain outside the town which is now all built upon.

Proposed Experimental Work

Mr W. H. Barreveld, Dutch FAO Junior Technician, is preparing to conduct experiments this year in tapping methods, Indian and local, and in the preparation from the sap of sugar instead of a beverage. As has already been noted the West Bengal State Gur Organiser accompanied by a tapper is visiting Libya shortly to demonstrate Indian practice.

SUMMARY

The date palm is widely tapped for its sap in North Africa but not in Arabia, Iraq or Persia. Tapping is common in Libya in all three provinces. The sweet sap contains about 10 per cent sucrose and is called *lagbi*, which name is also used for it when after a few hours it has fermented and become an alcoholic drink. In Libya *lagbi* is not used for sugar making. The annual production of this liquor on the coast of Tripolitania is about 17,500 hectolitres of a retail value of over £L 10,000. The production of this drink in the Fezzan may be as much but that of Cyrenaica is less. Mortality amongst palms tapped may be about 5 per cent. The same palm is not usually tapped more than two or three times in its life. Tapping in summer gives a much greater yield of sap than tapping in winter. On the coast of Tripolitania the legal tapping period is forty two days. In the Fezzan there are no restrictions. The first recorded mention of *lagbi* in modern times in a European language found by the present writer is that of Redi in 1666. There are several later references mostly by travellers who mention *lagbi* only incidentally.

(*Received June 1957*)

BIBLIOGRAPHY

The following list of publications contains all those, with the exceptions noted below, that refer to *lagbi* in modern times, which are in the writer's possession or are in the FAO Date Library, Tripoli. There are no doubt others, but these are not available owing to the remoteness of libraries.

As this note is concerned only with the production of *lagbi* at the present time it has not been considered necessary to include references to those works which record the tapping of date palms for *lagbi* in ancient Egypt.

Belgrave, C. D. (later Sir). (1923). *Siwa.* Lane, London. *Lagbi*, pp 157, 239, 241, 242

Blatter, E. (1926). *The Palms of British India and Ceylon.* Oxford University Press, London. *Lagbi*, pp 30, 31

Brown, T. W. (1924). *Date-Palm in Egypt.* Technical and Scientific Service, Horticultural Section, *Bulletin 43*, Ministry of Agriculture, Cairo. *Lagbi*, p 19

Burkill, I. H. (1935). *A Dictionary of the Economic Products of the Malay Peninsula.* Government of the Straits Settlements and Federated Malay States, Crown Agents, London. *Lagbi*, Vol. II, p 1713

Cauvet, C. S. (1901). 'La culture du palmier au Souf (1900–1).' *Bull. Soc. Hist. nat. Afr. N. No. 292.* Jourdan, Algiers. First quarter 1914, pp 29–87. *Lagbi* pp 28, 45, 46

de Cillis, E. (Quoted by A. Trotter. Not seen.) *Relazione Ministeriale.* (?) Rome. *Lagbi*, p 341

Cosson, E. and Jamin, P. (1855). 'De la culture du dattier dans les oasis des Ziban.' *Bull. Soc. bot. Fr.* **2**, *Lagbi*, pp 44, 45

Danthine, Hélène. (1937). *Le Palmier-dattier et les Arbres Sacrés dans l'iconographie de l'Asie Occidentale Ancienne.* Haut-Commissariat de la République Française en Syrie et au Liban, Service des Antiquités, Bibliothèque archéologique et historique, Geuthner, Paris. 2 volumes. *Lagbi*, Vol. I, p 22

DELCHEVALERIE, G. (1872). 'L'arbre national des Egyptiens, le Dattier (1871).' *Bull. Féd. Soc. Hort. Belg.* **5,** No. 13, pp 159–174. *Lagbi,* pp 163, 174

DRAR, M. (1950). 'Date palm in modern Egypt.' In TACKHOLM, V. and DRAR, M. *Flora of Egypt.* Faculty of Science of Fuad I University of Cairo, *Bulletin 28. Lagbi,* p 186

DUVEYRIER, H. (1864). (Not seen.) (F. MINUTILLI gives date as 1863.) *Exploration au Sahara: Les Touareg du Nord.* Challamel, Paris. *Lagbi,* p 198

FISCHER, T. (1881) *Die Dattelpalme.* Petermann's Mitteilungen Ergänzungsheft No. 64. Perthes, Gotha. 85 pp, 2 maps. *Lagbi* pp 26, 27

GASPERINI, G. (1913). (Quoted by A. TROTTER. Not seen.) 'Ulteriori studi sul vino di palma della Libya (*Laghbi o Leghbi*) con notizie sulla estrazione e sugli usi.' *Atti Accad. Georgof. Firenze,* Ser. V, **10,** disp. 1, pp 85–110

GASTINEL, B. (Note by, included in G. DELCHEVALERIE's *Le Dattier.*) *Lagbi,* p 174

GATIN, C. L. (1912). (Quoted by H. DANTHINE. Not seen.) *Les Palmiers. Histoire Naturelle et Horticole des Différents Genres.* (Encyclopédie scientifique). Doin, Paris. *Lagbi,* pp 142, 143

GUYON, D. (1855 or before). (Quoted by E. COSSON and P. JAMIN. Not seen.) *Voyage aux Ziban.* (?) Paris. Dates, pp 244–6

KRALIK, L. (1854). (Quoted by E. COSSON and P. Jamin. Not seen.) *Bull. Soc. bot. Fr.* **1.** *Lagbi,* p 26

LEHMANN, O. (1955). *Reisenotizen.* 'Du', Conzett and Huber, Zürich, May 1957. *Lagbi,* plates 19 and 20

LETHIELLEUX, J. (1948). *Le Fezzan, ses Jardins, ses Palmiers.* Publication de l'Institut des Belles Lettres Arabes, No. 12, Tunis. *Lagbi,* pp 226–7

LOUIS, A. (1945). (Quoted by J. LETHIELLEUX. Not seen.) *Aux Kerkennah, le Palmier et les Hommes.* Ibla. Pp 309–11

MAMOLI, P. (1888). (Quoted by F. MINUTILLI. Not seen.) 'Corrispondenze da Bengasi.' *Esplor. comm.* 1886–8. *Lagbi* at Derna

MIGLIORINI, E. (1937). *Risorse Economiche. Il Sahara Italiano: Fezzan e Oasi di Gat.* Reale Società Geografica Italiana, Parte prima. Società Italiana Arti Grafiche, Rome. *Lagbi,* pp 574, 576

MINUTILLI, F. (1912). *La Tripolitania.* Picc. Bib. di Sci. Mod., No. 44. Bocca, Torino. *Lagbi,* p 63

MONMARCHAIS, M. (1916). *Algérie et Tunisie.* Les Guides Bleus, Hachette, Paris. *Lagbi,* p 408

MORGANTINI, A. M. (1938). *La Libia Occidentale nei suoi Principali Aspetti Economico-statistici nel Quinquennio 1931–35, Lagbi,* p 7

NACHTIGAL, G. (1879–89). *Sahara und Sudan.* Berlin. 3 volumes. Vol. I, p 74. (Journey made in 1874–5)

PAOLETTI, A. (June, 1912). *La Palma da Datteri* (Phoenix dactilyfera) *in Egypt.* L'Agricoltura Coloniale, Year VI, No. 6. Istituto Agricolo Colonialo Italiano, Florence, pp 248–258. *Lagbi,* pp 257, 258

PERIN, M. (1933). (Quoted by H. DANTHINE. Not seen.) *Le Palmier-dattier.* Paris. *Lagbi,* p 70–71

REDI, F. (1666). 'Notizie intorno alla natur delle palme.' *Opere.* Vol. VI pp 185–196. Hertz, Venice, 1745. *Lagbi,* p 195. (? First account in European language of *lagbi* in Tripoli)

RHOLFS, G. (1878). *Viaggio da Tripoli all'Oasi di Kufra* (1878) (Abridged translation by G. CORA from *Reise durch Nord-Afrika von Tripoli nach Kufra.* Petermann's Geographische Mitteilungen, Ergänzungsheft No. 25. Perthes, Gotha) Vallardi, Milan, 1913. *Lagbi,* p 55

RIVIÈRE, C. and LECQ, H. (1914). *Traité Pratique d'Agriculture pour le Nord de l'Afrique* Challamel, Algiers. *Lagbi,* p 544

SCARIN, E. (1934). *Le Oasi del Fezzan.* Reale Istituto Superiore di Scienze Sociali e Politiche 'Cesare Alfieri', Centro di Studi Coloniali. Zanichelli, Bologna. *Lagbi,* pp 26, 182

SHAW, T. (1738). *Travels or Observations Relating to Several Parts of Barbary and the Levant* Theatre, Oxford. *Lagbi,* p 225

TÄCKHOLM, V. and DRAR, M. (1950). *Flora of Egypt.* Faculty of Science of Fuad I University of Cairo, *Bulletin 28,* Vol. II. *Lagbi,* pp 223, 224

Administration of Tripolitania, (1954). Department of Agriculture, Date File. *Lagbi,* Number of palms permitted

Governo della Tripolitania, (1913). *Reale Decreto, No. 292.* 'Col quale viene regolata l'estrazione del vino di palma (*Laghbi*) nella Tripolitania.' (Twelve articles: permit, tax, penalties, etc.)

TROTTER, A. (1915). *Flora Economica della Libia.* Unione Editrice, Rome. *Lagbi,* pp 101, 117–9

TUMIATI, D. (1905). *Tripolitania.* Treves, Milan, 1911. *Lagbi,* p 62

Lagmi, Vin de Palmier (1907). (Quoted by C. RIVIÈRE. Not seen.) *Bull. Tunis, No. 43,* Tunis

VOGEL, E. (1854). Central-Afrikanische Datteln. Bonplandia, Vol. II, p 6. Ruempler, Hannover. *Lagbi*, pp 74, 75
WATT, Sir G. (1908). *The Commercial Products of India.* Murray, London. *Lagbi*, p 885

A NOTE ON THE POLLINATION OF DATE PALMS

In REDI's account of the date palm, published in *Trop. Agriculture, Trin.* **33,** 207, 1956, the translator in his first note stated that this contained the first rational account he had come across in a European language of (amongst other things) the pollination of the date palm. He now wishes to add that since the translation was published he has rediscovered an earlier reference to pollination. This is in GEORGE SANDYS's *A Relation of a Iourney begun An. Dom. 1610*, Allott, London, 1632, in which on page 101 the author states:

'Of these [date palms in Egypt where Sandys was in 1611] there be male and female: both thrust forth cods (which are full of seeds like knotted strings) at the roote of their branches, but the female is onely fruitfull: and not so, vnless growing by the male, (towards whose vpright growth she inclines her crowne) and haue of his seeds commixed with hers; which in the beginning of March they no more faile to do, than to sow the earth at accustomed seasons.'

The female's inclining her crown to the male is, of course, nonsense, but the reference to the cultivator's not failing to pollinate in March is accurate. The comparison of the spikelets to knotted cords is apt.

Book Reviews

THE GROWTH OF LEAVES

Edited by F. L. MILTHORPE. Butterworths Scientific Publications: London; Academic Press Inc.: New York, 1956. x+223 *pp.* (illus.) 40*s*

The symposium entitled *The Growth of Leaves* is a report of the Proceedings of the Third Easter School in Agricultural Science held at the University of Nottingham in 1956 which has brought into focus certain fundamental aspects of leaf development together with an indication of some implications of practical significance. The symposium is edited by Prof. F. L. MILTHORPE who heads an impressive list of eminent workers in this field of research.

Apart from the useful information given in the last part of the book which contains a descriptive account of demonstrations in measurement and observation of leaf growth, the assemblage of papers follows the development of leaves from earliest initiation to maturity in four parts headed respectively, ' General Aspects of Growth and Differentiation ', ' Initiation of Leaf Primordia ', ' Leaf Expansion ', and ' The Influence of External Forces on Leaf Growth '. The reader is presented with the results of certain studies on leaf development with particular reference to the organization of meristems, the spatial and temporal relationships of leaf primordia initiation and subsequent development with attention drawn to the importance of the establishment of cell polarity as a prelude to differentiation. Some aspects of leaf expansion are dealt with in connection with variation and the mechanisms responsible, and also in relation to changes in the environmental conditions, particularly that of light—both photoperiodicity and complete absence of light—and the interaction between this factor and temperature. Certain metabolic activities associated with structural change have been reported from investigations on both root tips, which provide suitable and in some ways advantageous material for preliminary cell studies, and also a stem apex where, in addition to the measurement of anatomical features, the oxygen uptake, protein and total nitrogen contents have been investigated.

Whereas the earlier chapters of this work are largely of academic interest, it is in Part 4, dealing with the influence of environment on leaf growth, that the agriculturist concerned with increasing yields will find much for thought and, when more supporting evidence is available, possibilities for future exploitation. For example, the knowledge that a plant may never completely recover, in terms of leaf surface production, after a check in early development such as may result from an unfavourable environment at germination, should lead to further investigation of the optimum conditions for germination and for early phases of seedling development. The possibility of maintaining these optimum conditions before transplanting would be a

subsequent economic problem. It is in this section of the symposium that evidence is put forward in support of the claim that the effect of variation in the extent of the photosynthetic surface is of relatively greater importance in determining yield than the efficiency of the photosynthetic process; a restoration to some extent of a more balanced outlook between studies of the photosynthetic reaction itself (rate and mechanism) and those directed towards increasing leaf area and the duration of activity within the leaf. The recognition of this approach should be a foremost consideration in agricultural policy which in many regions of the world is directed more towards increasing yield from the areas of cultivation than extending the latter. Each chapter is followed by a list of relevant references and an account of the discussion arising from the contribution. An author and subject index completes the volume.

This valuable symposium, which makes clear the complex and diverse behaviour of leaves, should be available to all workers concerned with increasing agricultural production, for although it is impossible at this stage of the research to make conclusions and generalizations for immediate agricultural application, the symposium does mark a consolidation of recent ideas and leads to a greater understanding of some basic principles of leaf growth.—P.T.R.

PIONEER PEASANT COLONIZATION IN CEYLON

B. H. FARMER. Oxford University Press: London, 1957. xxvii+387 *pp.* (illus.) 55*s* (in U.K. only)

It would be of immense value to agriculture in the tropics if each major development scheme could attract an outside observer as capable, wise and sympathetic as Mr FARMER. Not only would sponsors of such schemes benefit from an impartial review of their activities but all workers concerned with similar developments would have much to learn from the experience of others. It is understandable but nevertheless unfortunately true that directors of development schemes are not themselves the best reporters of their own efforts; they are too close to their work, too occupied with detail, too much a part of the optimism or alternatively the disenchantment that pervades a scheme at the time of writing to be its best assessors. An outside observer of the quality of Mr FARMER is to the reviewer's mind as essential to pioneer development as the money and administration made available to launch it.

It is well known that until the introduction of pioneer 'colonization' schemes, about two thirds of the area of Ceylon was decadent, in the sense that this dry zone had seen better days as indicated by relics of ancient civilization, particularly of derelict 'tanks' for storage of irrigation water. The modern development of Ceylon has been concentrated on the establishment of agriculture, chiefly of estates producing export crops, in the highland third of the island. This development had led to a great increase in prosperity but also to an increase in economic instability and to a fearsome increase in the rate of population growth.

The establishment of colonization schemes around restored tanks is

therefore justified not only by sound economic and demographic considerations but by historical ones as well. Indeed one of the earliest handicaps of these schemes (which started as long ago as 1928) was the almost revivalist zeal for re-establishing the *Raja Rata*, the ancient kings' country, without careful calculation of the numerous difficulties and heavy costs involved.

The authorities have learnt patiently from their experience and the schemes at present in existence must be judged successful. Ceylon can boast of having settled over 16,000 families, nearly half of which have immigrated from the over-populated wet zone; that these families achieve a far higher standard of living (about Rs. 3000—£225—of which perhaps two thirds is in cash) than the average family dependent on agriculture, quoted as Rs. 1150—£86; that the extent and productivity of the schemes have increased local food production sufficiently to support 176,000 people at contemporary standards of nutrition; that, aided by DDT, the Government has dispelled the previously well founded fear of working and living in the dry zone.

The most instructive sections to the outside reader of this altogether instructive book are Mr FARMER's candid though sympathetic analyses of the problems still unsolved. He points out that the high income of colonists is due primarily to larger farms (3 to 5 acres of paddy) than are available to the average Ceylon peasant; yet the colonists have not yet been induced to pay land and water charges sufficient to cover maintenance cost, let alone the heavy capital expenditure both for irrigation work and settlement. They have not yet been persuaded to adopt more productive methods of cultivation particularly in respect of transplanting as opposed to broadcasting rice. They cannot become reconciled to a leasehold system of land tenure and often secretly circumvent it by private share-cropping arrangements. The colonies have not yet developed much social cohesion or self-reliance; the colonists lean heavily on the authorities even for so-called cooperative organizations and they still retain some caste distinction. The success of the colonies attracts an undesirably large number of squatters and landless labourers who have insufficient means of subsistence and encourage colonists in effect to become employers or share-crop landlords. The problem of permanent, productive use of the unirrigated land made available to colonists is still unsolved and this land is rapidly degraded to the loss of the colonists and to the danger of the irrigation works. Withal the required amount of capital and land suitable for irrigation is not available for these schemes to change the food production pattern of the country appreciably; during the last six years the colonies have produced food enough to support only one seventh of Ceylon's *increase* in population; they have been incapable of replacing any food imports.

From this necessarily incomplete list it can be appreciated that the problems of these schemes are formidable; but unless the problems are clearly recognized there is little hope of establishing better schemes of development in Ceylon or elsewhere and indeed little hope in the long term of the progress of tropical agriculture. The most able analysis presented in this book is in fact vital to the development of the tropics in the future; both Mr FARMER and the Royal Institute of International Affairs, under whose auspices this book is published, merit the congratulations and thanks of the tropical world.—A.L.J.

FIRST INTERNATIONAL CONFERENCE ON ANTIBIOTICS IN AGRICULTURE

NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL (*Publication 397*): Washington, 1956. xx+278 *pp.* (illus.) $2·50

Since the discovery that antibiotics could be used to increase the growth rates of young pigs and chicks, much work has been done on studies of the possible applications and mode of action of antibiotics in agriculture. The first international conference on the use of antibiotics in agriculture was organized by the National Academy of Sciences to enable specialist research workers in various fields of work on antibiotics to compare methods and progress to date, in addition to discussing future lines of study.

The conference was divided into five sessions: on growth response in animals, special biological problems, mode of action, crop usage, food preservation and public health aspects. The full text of the papers read at each, with the ensuing discussions and the relevant references, are given and make the record of the proceedings a very valuable reference book.

Of necessity the space devoted to each aspect of this rapidly expanding field of agricultural research is limited and it is evident that at future conferences it would be necessary to have different groups dealing with each set of topics concurrently in order to do justice to the information available. Despite this the report of the conference held in October 1955 is a very valuable summary of the work done and that still in progress at the world's leading centres of research into the use of antibiotics. As such it is a unique record and extremely useful in correlating much of the increasing volume of information which has been independently published in the last few years.—T.R.H.

DICTIONNAIRE DES HUILES VÉGÉTALES

P. H. MENSIER. Editions Paul Lechevalier: Paris, 1957. viii+763 *pp.* Fr. fr. 10,000

The author of this work is to be congratulated upon having produced a compact yet extensive survey of the vegetable fats, which will undoubtedly prove to be a useful work of reference in technical and university libraries. The fats described are derived from a very wide range of plants including both cultivated and wild species and the text is particularly laudable in relation to species of plants encountered in tropical regions, which have been very adequately treated.

It is to be regretted, however, that references to original papers are not given, since in a work of this sort detail must be necessarily restricted and some measure of guidance to the rather scattered literature of the subject would have been of considerable value to the research worker.

The surprisingly high lipid content of certain hitherto uncultivated plants should suggest, to those interested in the development of new sources of vegetable fat, profitable lines of research. Much of the material will be of interest also to the academic scientist interested in the possible correlation between the chemical composition of a species and its systematic position, although from this point of view, it is to be regretted that information relating

to the fatty acid constituents of the lesser known species is somewhat limited.—L.A.G.

TIMOR e A CULTURA do CAFÉ

HÉLDER LAINS E SILVA. Overseas Ministry: Lisbon, 1956. xiii+196 *pp.* With photographs and maps. Price not quoted

Though few British readers are aware of Portuguese publications on tropical agriculture, two important series are in course of production. The first, which includes over 20 slim volumes published during the last ten years, is entitled ' Estudos, Ensaios, e Documentos ' and is published by the Overseas Research Council of the Overseas Ministry in Portugal. A number of these titles are of direct agricultural interest, as the following examples will show: *Aspects of the Problem of Soil Erosion in Africa* by J. BOTELHO DA COSTA, *Groundnut Cultivation in the Economic Development Plan of Mozambique* by F. MONTEIRO GRILO, *Insect Pests of Tobacco* by A. ANTUNES DE ALMEIDA, and *Studies on the Cultivation of Tea in Mozambique* by HÉLDER LAINS E SILVA.

It is the last-named author who has also written the book now under review. This is No. 1 in a new series entitled ' Memórias: Série de Agronomia Tropical ', which is also published by the Overseas Research Council. The book includes an English summary of the text in 9 pages.

Coffee has long replaced sandalwood as the main export of Portuguese Timor, but it is thought that there are considerable prospects for expansion. The author's task has been to try to define these prospects. After a full discussion of local climate and soils, he delineates the most promising areas which are shown on excellent maps, and suggests where experimental stations should be sited. The areas suitable for Arabica coffee is limited to highlands of between 1000 and 2000 metres altitude, below which it suffers badly from *Hemileia* disease, though some hope is placed in clones which appear to be resistant to the fungus and may permit cultivation down to 600 metres. The areas suitable for Robusta and Liberica are much more extensive. At present much coffee is grown under *Casuarina* shade, but *Albizzia moluccana* is coming into increasing use for the purpose.—G.B.M.

NOTES FOR AUTHORS

The editors of *Tropical Agriculture* would be glad to receive and consider manuscripts for publication, especially from tropical countries. Two types of articles are acceptable: (a) original research papers, (b) review or survey articles dealing with progress in a branch of science relevant to tropical agriculture. In the latter category, articles by agricultural officers describing problems or progress in their region are welcomed, provided that the subject matter is of more than purely local significance.

Contributions submitted from the Caribbean area should be addressed to the College Editor (The Principal, The Imperial College of Tropical Agriculture, Trinidad, B.W.I.); from all other areas to the General Editor (G. B. Masefield, Department of Agriculture, Parks Road, Oxford, England). It is understood that manuscripts are not offered to any other journal for prior or simultaneous publication. Authors who are Government servants should include, either in the text or in a covering letter, a statement that they have the approval of their Government for publication. Manuscripts are normally acceptable in English only; in special instances translation may be arranged but such material should not be submitted without first consulting the editor. Articles should not normally exceed 6000 words, but longer ones can occasionally be accepted if the subject matter is of special interest and not suitable for subdivision.

Manuscripts must be in typescript on one side of the paper only, with double-line spacing and ample margins. Sheets should be numbered consecutively. The following order should be observed: title of paper; author's name (academic degrees and honours are not printed); a brief indication of the author's place of work or official position; text; summary (for all research papers and for general articles where suitable); acknowledgements; references.

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Tables should be as simple as possible and must be of a size and form that can fit into one page of size 4½ in. x 7½ in. Each table should be typed on a separate sheet and the approximate position of each table marked in the text. Captions for tables should appear at the head and should be numbered consecutively in Arabic numerals.

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Flora of Trinidad and Tobago: This Flora, which has been issued irregularly in parts since 1928, is a compilation of the work of many authors. The early parts, mainly by R. O. WILLIAMS, were edited by the Department of Agriculture of Trinidad and Tobago, but since the end of the 1939–45 war editing has been taken over by the Botany Department of the Imperial College. The Flora may be obtained either from the Department of Agriculture or from the Imperial College. The following parts have been published :

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